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PROCEEDINGS OF THE FIFTY-SIXTH ANNUAL MEETING OF THE IOWA ACADEMY OF SCIENCE

Held at Mt. Pleasant, March 17 and 18, 1942

MINUTES OF THE 1942 MEETING

The fifty-sixth meeting of the Iowa Academy of Science was called to order by President Nelson in the Iowa Wesleyan Chapel at 10:30 a. m., April 17, 1942. The following committees were appointed by the President:

Necrology: Peterson, Lindstrom, Herr

Resolutions: Peterson, Huff, Raiford

Nominations: McClenon, Trowbridge, Gouwens, Carter, Martin

The Academy was officially welcomed to the campus of Iowa Wesleyan College by President Stanley B. Niles. Since 1942 was the year of its centenary celebration, President Niles presented a review of the history, accomplishments, and objectives of Iowa Wesleyan.

The presidential address by Dr. Nelson of Cornell College was a development of his announced subject, *Science in a Changing World.* Immediately afterwards Dr. Walter F. Loehwing of the State University gave an invitation address on *Nutritional Factors in Plant Growth and Development.*

Friday afternoon, 1:30 - 3:00, academy members attended the customary joint symposium with the Iowa Medical Society presided over by Dr. H. E. Rath. *Industrial Hygiene Problems in Iowa* was the topic discussed by Dr. Paul J. Hauser, Director of Hygiene, Iowa State Department of Health. This paper was followed by one on *Air-Borne Infection* by Dr. Roland Rooks of the Department of Hygiene and Preventive Medicine, State University.

There were 130 diners at the All-Academy Dinner Friday evening in Hershey Hall. Dr. T. F. Vance of the State College delivered a sparkling dinner address entitled *Sense and Nonsense Amid the Scientific.*

The special feature of the meeting, the Academy Address, was delivered this year by Dr. George E. Stoddard, Dean of the Graduate College, State University. His subject, *New Light in Intelligence,* was developed in a discussion of the effect of "nature and nurture" on the intelligence quotient.

As is customary, the various sections of the Academy met on Friday afternoon and Saturday morning, adjourning on Saturday in time for the business session in the Chapel at 11:00 a. m.

Reports of the Executive Committee, Secretary, Treasurer, Auditing Committee, Editor, Finance Committee, High School Relations Committee, Necrology Committee, Biological Survey Committee, and Conservation Committee were read and accepted upon motion.

The Secretary's recommendation that the Constitution and By-Laws be recoded by a committee appointed by the President and presented to the 1943 meeting of the Academy for approval was adopted upon motion.

The report of the Biological Survey committee contained a recommendation that the resignation of the Committee be accepted. Upon motion the report of the Committee was accepted striking out all reference to resignation.

A motion by M. L. Grant that the name of the Botany-Bacteriology Section be changed to Botany Section provoked considerable discussion. The motion suggesting the change was approved by the vote of the members.

The Nominating Committee presented the following slate of officers for the year 1942-43:

President, C. W. Lantz, Cedar Falls
Vice-President, E. R. Smith, Ames
Secretary-Treasurer, E. R. Becker, Ames
Editor, L. R. Wilson, Coe College.

The section chairmen and representatives of sections on the Executive Committee were announced as follows:

Section	*Chairman*	*Executive Committeeman*	
Botany	W. E. Loomis	Louisa Sargent	(1939-1943)
Chemistry, General and Physical	D. L. Deardorff	Jacob Cornog	(1941-1945)
Chemistry, Organic, Biological	F. B. Moreland	B. H. Peterson	(1939-1943)
Geology	E. J. Cable	A. K. Miller	(1942-1946)
Mathematics	N. B. Conkwright	C. Gouwens	(1940-1944)
Physics	L. T. Earls	Roy A. Nelson	(1942-1946)
Psychology	H. F. Brandt	A. H. Lauer	(1941-1945)
Science Teaching	K. A. Stiles	M. F. McDonald	(1942-1946)
Zoology	Leland P. Johnson	T. L. Jahn	(1942-1946)

Announcement was made that the 1943 meeting of the Iowa Academy of Science will be held in Cedar Falls.

A motion to adjourn was adopted.

E. R. BECKER, *Secretary*.

REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee met in the Mathematics Room, Old Main, at 1:30 p. m., April 17. President Roy A. Nelson presided. The following members were present: Lantz, Wilson, Conard, Aikman, Kambly, Culbertson, Sargent, Peterson, Gwynne, Gouwens, Jaques, and Becker.

The Secretary's report containing the recommendation that the constitution and by-laws be revised during the year 1942-1943 and be published in the 1943 *Proceedings* was discussed and approved.

The A. A. A. S. grant of $123.50 for research and $26.50 additional to be taken from the 1942 income of the Academy from the endowment fund were appropriated for investigations now being conducted by Ben H. Peterson, Wm. M. Goldsmith, and T. C. Stephens. The desirability of increased funds for research was discussed.

The committee previously appointed to investigate the feasibility of a Collegiate Academy in Iowa reported to the effect that it did not consider it advisable to recommend that efforts be made to establish such an institution under present war conditions. A motion that the report be accepted and the committee released was adopted.

G. L. Wittrock was appointed official delegate to the Torrey Botanical Club's celebration of the 75th Anniversary of its Foundation in New York on June 22, 1942.

The usual $100 was appropriated to the Junior Academy of Science of Iowa, apportioned as follows: honorarium, Permanent Secretary, $25; current expenses, $75.

At its 1941 meeting the Executive Committee delegated Dr. Karl A. Stiles to prepare a scientific book exhibit of Iowa authors at its 1943 meeting in Cedar Falls. Upon reconsideration the preparing of the exhibit has been left to the discretion of Dr. Stiles.

Cedar Falls was definitely selected for the 1943 meeting, while no decision was made for the place of the 1944 meeting.

Respectfully submitted,
E. R. Becker, *Secretary*

REPORT OF THE SECRETARY 1941 - 1942

In planning my first annual report as Secretary of the Iowa Academy of Science, I am confronted with the problem of what should be the nature and scope of such a report. This year I started calling the mimeographed sheet announcing the annual meeting *Secretary's* Letter. It is my hope that in the course of time this letter will develop into a medium of expression between the Secretary's office and the membership that will largely supplant much of the material formerly appearing in the Secretary's published report. The letter has the advantage of being more informal and personal, and in it can be discussed matters not intended for the permanent record. If it does arouse more interest on the part of members in the conduct of Academy affairs it will have had the desired effect, for after a year's experience in office, I feel very keenly the apathy on the part of the membership in this regard.

As the treasurer's report indicates, the finances of the Academy are in excellent condition with a total of about $5.00 per member in the endowment fund and about $0.40 per member in the cash balance. I feel it is particularly desirable that at the present time the Academy maintain as strong a cash balance as possible.

Constitution of the membership is practically the same as the list appearing in Vol. XLVIII of the *Proceedings*. The total of 681 members was distributed as follows: honorary fellows, 4; emeritus fellows, 3; life fellows, 22; fellows, 291; associates, 361. It will doubtless require strenuous efforts on the part of the membership committee and the general membership if we are to preserve this strong position.

The Junior Academy of Science is having its troubles. *The American Institute*, with which it had a cooperative agreement, has transferred its interests in junior academies to the *Science Clubs of America*. There were certain aspects of the deal that have drawn the sharp disapproval of the General Secretary of the American Association for the Advancement of Science and some of the members who attended the last Academy Conference at Dallas, Tex. The Academy Conference has a committee appointed to investigate the whole situation relative to the relations between Junior Academies and Science Clubs of America and to make a report. Meanwhile our own Junior Academy is carrying on more or less independently, though some of the clubs are subscribing to the services offered by the S. C. A. It is our hope that in the near future an agreement will be worked out between the Science Clubs of America and our own Junior Academy.

The secretary's report of last year, prepared by Dr. J. C. Gilman, contained a recommendation that the Academy set up a program committee (quote) to relieve the Secretary of the burden of the general program for the meeting and to look after the entire arrangement of time of meetings and avoidance of conflicts. This committee was to consist of the vice-president, who would serve as chairman, and three other members, one representing medical science, another teaching interests, and one a member-at-large. His recommendation was adopted at the last meeting, and the President appointed the following committee: C. W. Lantz, (chairman), M. E. Barnes, S. M. Dietz, and B. H. Peterson. This committee, in consultation with the Local Committee at Mt. Pleasant and the President and Secretary of the Academy proceeded to prepare the general program and, in its first test, attained effectively the objectives of the one who conceived it. It is the Secretary's hope that suggestions will from time to time be forwarded to this committee from the membership so that it will be cognizant of the kind of programs the membership desires.

It seems that the time has come again when the constitution and by-laws should be reprinted. Before this is done a committee should be appointed to reformulate them. The secretary recommends that the President for 1942-43 appoint a committee to accomplish the stated purpose, and that the new formulation of constitution and by-laws be submitted to the fellows of the Academy in accordance with Section 8 of our present constitution.

Respectfully submitted.

E. R. BECKER,
Secretary-Treasurer
(April 18, 1942)

REPORT OF THE TREASURER

RECEIPTS 1941-1942

Cash on hand March 1, 1941	$ 227.90
Dues	614.30
Sales	23.83
A. A. A. Grant	125.00
Interest	29.49
Dividend, Union Story Trust and Savings Bank	23.09
	$ 1043.61

DISBURSEMENTS 1941-42

Postage	$ 73.41
Clerical help	13.50
Printing, addressograph, etc.	156.07
Honoraria	200.00
Editor's Office, Vols. 47 and 48	31.19
Junior Academy, including honorarium for Permanent Secretary	100.00
Research grants	
A. A. A. S.	125.00
Iowa Academy	50.00
A. A. A. S. meeting	35.00
	$ 784.17
To balance	259.44
	$ 1043.61

ENDOWMENT FUND

Balance Mch. 1, 1941	$ 567.47
Fees from fellows	14.00
1 life membership	20.00
Interest on savings account	12.21
Cash on hand	$ 613.68

HOLDINGS

Federal Farm Mortgage Bond, 1949	$ 500.00
Federal Farm Mortgage Bond, 1964	500.00
U. S. Treasury Bonds 3¼%, 1946	300.00
U. S. Savings Bonds, 1949	675.00
Midland Investment Corp. Pfd. Stock (2 shares)	200.00
Midland Theatre First Mtg. Bond 1953	300.00
Account, Union Story Tr. & Sav. Bank	613.68
Total	$ 3088.68

Respectfully submitted,

E. R. BECKER, *Treasurer*

Your committee appointed to audit the books of the Iowa Academy of Science wish to make the following report. We have received the books from the Secretary and Treasurer, E. R. Becker, and carefully checked the assets and liabilities of the Academy and find that the records are correct.

Joseph C. Gilman
E. W. Lindstrom
F. E. Brown
(March 1, 1942)

REPORT OF THE FINANCE COMMITTEE

The report of the Academy Treasurer on "Receipts" and "Disbursements" has been examined by the Finance Committee and is approved.

Our secretary-treasurer, E. R. Becker, requested an audit of the books of the Iowa Academy of Science including a check of the assets and liabilities of the Academy. This committee, appointed by Academy President Nelson, consisted of J. C. Gilman, E. W. Lindstrom, and F. E. Brown. They found the records correct.

Members of the Committee
U. A. Hauber
E. W. Lindstrom
H. S. Nollen
J. B. Culbertson, *Chairman.*
(April 18, 1942)

REPORT OF THE MEMBERSHIP COMMITTEE

The membership committee submits application cards for 62 new members and recommends their election to the Academy. These applications are divided as follows:

1	Life Fellow
13	Fellows
48	Associates

R. W. Getchel
D. L. Holl
L. D. Weld
Paul E. Kambly, *Chairman*
(April 18, 1942)

LIFE FELLOW

Wilson, L. R., Geology and Botany, Coe College, Cedar Rapids.

New Fellows

Anderson, R. B., Chemistry, State University of Iowa, Iowa City, Iowa
Berg, William D., Mathematics, Iowa City, Iowa.
Boyer, Dr. E. H., Pathology, St. Vincent's Hospital, Sioux City.

Crawford, L. C., Hydraulic Engin. and Conserv., 508 HL, Iowa City.
Ernsdorff, L. E. Mathematics, Loras College, Dubuque.
Geisler, George, Chemistry, Trinity College, Sioux City.
Galligan, W. E., Hydraulics, Engineering Hall, State College, Ames.
Hodgson, James B., Philosophy, Coe College, Cedar Rapids, Iowa.
Houtchens, H. Max, Psychology, Child Guidance Center, Des Moines.
Luck, Robena E., Botany (Plant Pathology), 942 Iowa Ave., Iowa City.
Nye, Warren E., Biology, Loras College, Dubuque.
Routh, J. I., Biochemistry, State University, Iowa City.
Stork, F. J., Chemistry, Loras College, Dubuque.

NEW ASSOCIATES

Adams, Michael, Psychology, State University, Iowa City.
Albert, W. E., Fisheries Supervisor, Lansing.
Anderson, Stanley, Psychology, Morningside College, Sioux City, Iowa.
Baker, H. T., Chemistry, 511 So. Madison, Iowa City.
Beebe, J. M., Bacteriology, State College, Ames.
Boardman, Donald C., Geology, State University, Iowa City.
Boardman, W. W., Chemistry, State University, Iowa City.
Bragonier, W. H., Botany, State College, Ames.
Brown, George W., Metallurgical Chem., State University, Iowa City.
Crabb, Dayrle N., 206 Steffens Hall, University of Dubuque, Dubuque.
Craft, James H., Plant Physiology, State University, Iowa City.
Cuthbert, Nicholas L., 410 W. Monroe, Mt. Pleasant.
Davis, Arthur W., Engin. Mech., Theor. and App. Mech. State College, Ames, Iowa.
De Buchanne, George D., Geology, 18 No. Dodge, Iowa City.
De Garmo, J. L., Psychology, 1301 So. Glass, Sioux City.
Edmondson, Mary Louise, Psychology, 2118 Sunset Drive, Ames.
Floyd, Don E., Organic Chemistry, Iowa City, Iowa.
Gilman, Ruth, Botany, Grinnell College, Grinnell.
Gray, Warren, Geology, 1125 E. Burlington, Iowa City.
Goodman, John, Botany and Zoology, Parsons College, Fairfield.
Grumbein, Mary Louise, Mycol. Bot. Dept., State University, Iowa City.
Hannah, Wayne, Chemistry, State College, Ames.
Hemmings, William A., Hillsboro.
Hertel, Elmer W., Biology, Wartburg College, Waverly, Iowa.
Irwin, Orvis C., Iowa Child Welfare Research Station, Iowa City.
Johnson, I. J., Plant Breeding, State College, Ames.
Jenness, J. R., Physics, Parsons College, Fairfield.
Lentz, Paul L., Botany, State University, Iowa City.
Levin, Arthur, Parasitology, 418 S. Van Buren, Iowa City.
Lovell, Geo. D., Psychology, Psychology Dept., Grinnell College, Grinnell.
Matthews, John M., Geology, 724 N. Dubuque, Iowa City.
McComb, A. L., Forestry and Botany, 420 Briarwood, Ames.
McIlrath, Wayne, Botany, State Teachers College, Cedar Falls.
Morehouse, Neal F., Parasitology, 205 Fourth Ave., Charles City.
Nettleton, Guy, Jr., Biology, Morningside College, Sioux City.
Norton, R. A., Agric. Engin., 915 Gaskill Drive, Ames.
Parizek, Eldon J., Geology, 917 Fairchild St., Iowa City
Payton, Marcus, Geology, 221 N. Linn, Iowa City.

Rooks, Roland, Hyg. and Prev. Medicine, State Univ. Hosp. Iowa City.
Schwob, F. T., State Director of Conservation, Des Moines.
Show, Franklin J., Psychology, 217 S. Gilbert, Iowa City.
Shupe, Leonard, Psychology, High School, Audubon.
Spence, Kenneth W., Psychology, State University, Iowa City.
Stevens, Norman, Physics, 308 E. Church, Iowa City.
Sybil, Edward W., Botany, State University, Iowa City.
Thompson, Bonnie J., Botany, Crawfordsville.
Thompson, John David, Zoology, State University, Iowa City.
Tudor, W. J., Psychology, State College, Ames.
Winterstein, Merryn G., Chemistry, 829 No. Fifth, Burlington.
Yeager, Bob, Zoology (Pre-Med.), 3800 Garretson, Sioux City.
Yeager, Walter, Zoology, (Pre-Med.), 3800 Garretson, Sioux City.

REPORT OF THE EDITOR

The Proceedings of the Iowa Academy of Science for 1941 are published in volume 48. The publication contains 496 pages of which the first 47 are devoted to the list of members, reports of officers, committees, and the In Memoriam section. The portion containing papers and abstracts of research by 147 Academy members totals 439 pages. The index is 10 pages in length.

The editor wishes to express his appreciation to the chairmen of sections and the authors who assisted greatly in making possible the prompt publication of the Proceedings. He also wishes to express his appreciation to Mrs. Florence W. Nichols, the former editor, and to Dr. J. C. Gilman, the former Secretary-Treasurer, for invaluable suggestions in the preparation of the present volume. The assistance of the State Printer, Mr. L. M. Shaw, and many others is gratefully acknowledged.

Respectfully submitted,
L. R. WILSON, *Editor*
April 18, 1942.

THE REPORT OF THE LIBRARIAN, IOWA STATE COLLEGE LIBRARY, TO THE IOWA ACADEMY OF SCIENCE FOR THE YEAR ENDING ON FEBRUARY 28, 1942

During the year 1941-42, the distribution of the Proceedings of the Iowa Academy of Science to institutions in foreign countries was greatly curtailed because of the war. Since December 7, 1941, the Library has sent out only the volumes designated for individuals and institutions in this hemisphere and to certain institutions in Great Britain which expressly requested that their copies be forwarded. The volumes not forwarded will be held by the Library for the duration. Similarly, many foreign institutions are now holding publications which are normally sent us on exchange for the Proceedings. The figures which follow, therefore, do not represent the series actually received, but the number of publications due us on exchange.

Number Of Institutions On Mailing List:

Domestic	124
Foreign	60
	184

Number Of Publications Normally Received From These Institutions:

Domestic	367
Foreign	230
	597

Number of Publications Received in Direct Exchange:

Domestic	62	from	44	institutions
Foreign	23	"	21	"
	85		65	

Number of Publications Normally Received in Exchange for Iowa Academy of Science Proceedings Plus Publications of Iowa State College:

Domestic	305	from	52	institutions
Foreign	145	"	37	"
	450		89	

Note: *These publications are normally received for a combination of the Iowa Academy of Science Proceedings with any of the following: Iowa State College Journal of Science, Iowa Agricultural Experiment Station publications, Iowa Engineering Experiment Station Bulletin.*

Institutions Receiving the Proceedings as Gifts:

6	U. S. Government Agencies
22	Iowa Libraries
2	Foreign Institutions (For abstracting)
30	

Distribution of Iowa Academy of Science Proceedings:

Number of copies

	vol. 47	vol. 48
Membership	675	669
Exchange	189	190
Subscription	13	9

Respectfully submitted,

C. H. Brown, *Librarian*

REPORT OF THE COMMITTEE ON BIOLOGICAL SURVEY

To the Iowa Academy of Science:

The Committee on Biological Survey has circulated one letter among its members, containing a report of a project carried on by a similar committee of the Missouri Academy. We have taken no action during the year. It is recommended that a new committee be appointed, based on a plan to cooperate with State and local organizations interested in wildlife and conservation.

Respectfully,

T. C. Stephens
R. B. Wylie
H. E. Jaques
H. S. Conard, *Chairman*
April 18, 1942

REPORT OF THE CONSERVATION COMMITTEE OF THE IOWA ACADEMY OF SCIENCE

The chief accomplishments of the past year are the reorganization of the committee, the division of interests and duties and the making of plans for the coming year. It is the opinion of the committee that now, as at no time since the early years following the organization of the conservation committee, there is an opportunity for the Academy to make a lasting contribution to the conservation program of the state.

In contrast to a lack of knowledge and appreciation of conservation in the early days and the absence of a conservation program, there is now a somewhat general understanding and appreciation of the principles of conservation and a well developed program administered by the Iowa Conservation Commission. In addition to this program, the Soil Conservation Service of the U. S. Department of Agriculture has been active in the state in the development of demonstration projects and in cooperative S. C. S. camp work on privately owned farms. The formation of conservation districts throughout the state has at last placed the responsibility for the action program in soil and water conservation in the hands of the farmer. The rise of county and city conservation organizations in the last few years is evidence of the spread of the conservation spirit among dwellers in cities and towns. In spite of all of the conservation work done in the state, however, it can readily be observed that there is much remaining to be done.

The selection of new members of the committee and the division of duties were made on the basis of work to be done. The assignments are:

1. General wildlife interest throughout the state and preserves and parks. Carter and Doty.
2. Game management. Hendrickson.
3. Fish management. Speaker.
4. Archeology. Keyes.

5. Water supply. Galligan.
6. Forests. McDonald.
7. Soil and water conservation. Dodge and Aikman.

In order to clarify the responsibilities of the Academy and the Conservation Committee to the conservation program in the state, the following points may be listed:

1. Responsibility of the Conservation Committee to the Iowa Academy of Science:
   (1) Organization and presentation of information on the activities in the several fields of conservation work in Iowa. Records, reports and programs.
   (2) Recommendations to the Academy relative to opportunities for service to conservation agencies and fields.
   (3) The formulation of a constructive, coordinated conservation policy and program to present to the Academy for its consideration.
2. Recommended service of the Iowa Academy to conservation in Iowa:
   (1) A fostering interest in all worthwhile conservation enterprises.
   (2) The contribution of individual members, specialists in conservation or in supporting fields, to the general conservation program in the state.
   (3) Establish a constructive coordinated conservation policy and program and follow them.

Respectfully submitted,

Charles Carter
A. F. Dodge
H. S. Doty
W. E. Galligan
G. O. Hendrickson
C. R. Keyes
G. B. McDonald
Everett Speaker
J. M. Aikman, *Chairman*
April 18, 1942

REPORT OF THE HIGH SCHOOL RELATIONS COMMITTEE
1942

The Junior Academy has had a successful year. The schools that participate are quite enthusiastic; however, there is need for extending the work into a larger number of high schools.

The American Institute of New York City with whom we were affiliated has transferred its sponsorship of Science Clubs to the Science Clubs of America, which is backed by Science Service. The plans for our relationship with this organization have not yet been worked out. In fact, the change has caused some confusion in our relationship to the science clubs in the state. We are hoping that the details of this relationship can be worked out this year to stimulate more interest in club work in the state.

The annual convention was held at the Mt. Pleasant High School. The attendance was 120. We wish to express our appreciation to the faculty and students of the local high school for their splendid hospitality and cooperation.

While the projects exhibited this year were not so extensive, the quality was high. The awards made are as follows:

Biological Sciences

Superior—Wilson High School, Cedar Rapids
Excellent—Iowa City High School
Excellent—Marion High School

Physical Sciences

Superior—Iowa City High School
Excellent—Marion High School
Excellent—Cedar Falls High School

General Science

Excellent—Amos Hiatt Junior High School, Des Moines

Essay

Superior—Helen Madsen—"Gases in Warfare"—Cedar Falls High School
Superior—Marjorie Mach—"Helium"—Cedar Falls High School
Superior—Gordon Valentine—"Friction and Lubrication"—Cedar Falls High School
Excellent—Esther Etzel—"Spiders"—Marion High School
Excellent—Cecil Johnson—East High School, Sioux City

The officers elected by the Junior Academy for the year 1942-43 are:

President—Thelma Fleming—Cedar Falls High School
Vice President—John Dawson—East High School, Des Moines
Secretary—Bill Kempshall—Marion High School
Treasurer—James Gaffney—Cedar Falls High School

The Committee asks the Iowa Academy to confirm the appointment of the following officers for next year:

Senior Councilor—Arthur Haupt—Marion High School
Junior Councilor—Clifford Johnson—Dubuque Senior High School
Permanent Secretary—D. C. Stroud—Amos Hiatt Junior High School, Des Moines

We wish especially to commend Mr. Charles Trachsell of Iowa City High School and Mr. Arthur Haupt of Marion High School for their devoted services as councilors during the year.

Respectfully submitted,
High School Relations Committee
F. E. BROWN
PAUL RISLEY
D. C. STROUD
E. R. BECKER
C. W. LANTZ

REPORT OF THE COMMITTEE ON RESOLUTIONS

The Committee on Resolutions submits the following resolutions and recommends their adoption and incorporation in the Proceedings.

1. That the Iowa Academy of Science extend to Iowa Wesleyan College congratulations upon the celebration of the Centennial, and that the Iowa Academy by this resolution recognizes and hereby expresses its appreciation of the services rendered the people of Iowa by the hundred years of leadership in the development of the State.
2. That the officers and members of the Iowa Academy of Science extend their sincere appreciation and thanks to the president, faculty and student body of Iowa Wesleyan College for the hospitality and excellent arrangements provided for the fifty-sixth meeting of the Academy.
3. That the Iowa Academy of Science reaffirm the resolutions of the fifty-fifth meeting relative to National Defense.

Respectfully submitted,

Ben H. Peterson
George C. Huff
L. Charles Raiford

In Memorium

John Alexander McGeoch
1897—1942

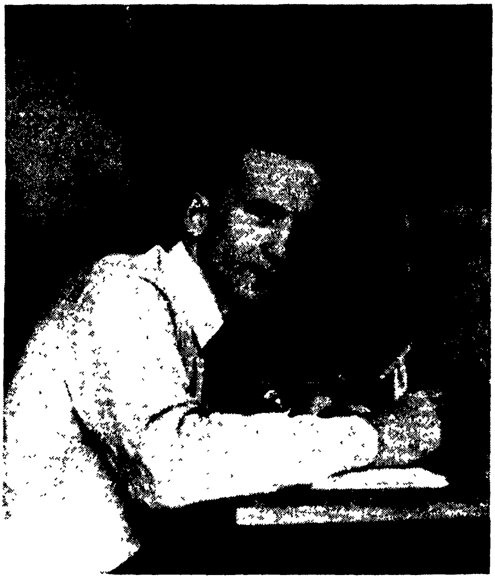
Professor McGeoch came to Iowa as professor and head of the Department of Psychology in the fall of 1939. He came to an untimely death on March 3, 1942, as a result of a cerebal hemorrhage. He came to us recognized as one of the outstanding psychologists of the present generation and during his brief stay here gained recognition for his scholarly activities, his wise administration, and his winsome personality in all his associations on the campus.

He was born in New York but was educated in the middle west. Before coming to Iowa he had held responsible positions in Washington University, the University of Missouri, and Wesleyan University, where he held a research professorship.

His principal field of investigation centered around the analysis of the learning process and just before his death he had finished his magnum opus "The Psychology of Human Learning," which is being published by Longmans, Green.

Iowa mourns the loss of this distinguished scholar.

Carl E. Seashore
State University of Iowa



EDGAR W. TIMM
1916—1942

EDGAR W. TIMM, Research Assistant in Genetics at the Iowa State College, a brilliant young scientist, died very suddenly of a cerebral hemorrhage on March 26, 1942 at the age of twenty-six. Born in Muscatine, Iowa, where he is survived by his father and two brothers. Timm had his secondary education at the Muscatine High School (1928-1932). He entered Iowa State College in 1932 and graduated with honors in 1936 with the B. S. degree in chemical technology.

As a result of his exceptional academic career and his fine personality, he was the unanimous choice for the Rhodes Scholarship, the first from Iowa State College. He spent two years at Oxford University, Trinity College, receiving a B.Sc. degree there in 1938. From this study, he published two papers in reaction kinetics, one with the noted head of his department, Dr. C. N. Hinshelwood. As a reward for this accomplishment, he was granted a third year at Oxford which was devoted largely to work in biology and genetics. He spent six weeks at the famous John Innes Institution for Genetics at Merton; and traveled widely during vacation periods. A third publication on hybridity and polyploidy of an Oxford rush, Juncus, resulted from this final year of work in England. By this time, Timm had decided on a career in Genetics and was offered a graduate assistantship in the Genetics Department of Iowa State College. In the fall of 1939, before returning home, he was a delegate at the International Congress of Genetics at Edinburgh, Scotland.

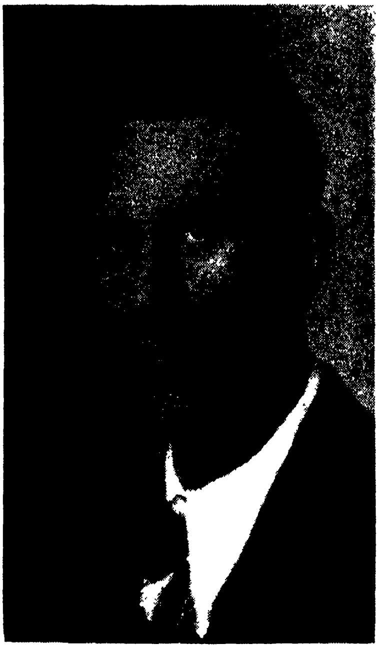
From 1939-1941 Timm served as graduate assistant in the Genetics Department of Iowa State College, maintaining the same 'straight A' record of his former years. He was an unusually keen observer and thinker, with a marked flair for mathematical applications. His researches dealt with bacterial genetics, particularly the mutation aspect of virulence in the bacterial wilt pathogen of maize. Timm possessed rare ability in planning experiments. His colleagues and graduate students of the department leaned on him for direction and his profound influence on their ideas will remain as a heritage for long.

In 1940, Timm married Helen Waldron of Des Moines, a graduate of Iowa State College in the class of 1940. She proved to be a devoted collaborator in Timm's research. At this time, when Timm's Ph.D. research was practically complete, he was appointed as full time Research Assistant on a Rockefeller Foundation project, continuing with the bacterial genetics work on a larger scale. He was blazing new paths in critical studies of bacterial variation and mutation when, without warning he was stricken at the end of a day's work.

Publications.

1. Hinshelwood, C. N., K. J. Laidler, and E. W. Timm. The activation energy of organic reactions. Part I. Electronic theories of organic chemistry from the standpoint of chemical kinetics. Journal of the Chemical Society, 1938:848-858.
2. Timm, E. W. and C. N. Hinshelwood. The activation energy of organic reactions. Part III. The kinetics of acid hydrolysis of esters. Journal of the Chemical Society, 1938:862-869.
3. Timm, E. W. and Clapham, A. R. Jointed rushes of the Oxford district. New Phytol. 39:1-16. 1940.
4. Timm, E. W. Theoretical Genetics. Iowa Academy Sci. Proc. 48:51-58. 1941.

E. W. Lindstrom
Iowa State College,
Ames, Iowa



Oliver W. Muelder
1912—1941

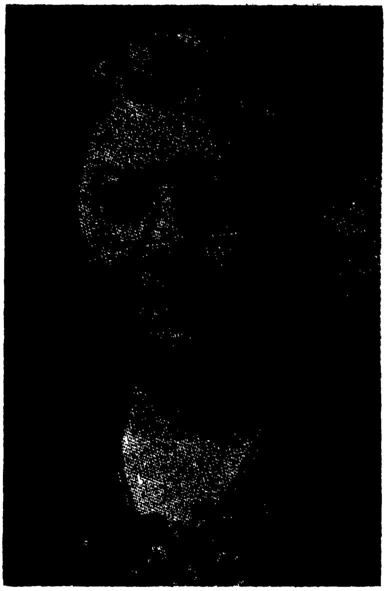
Oliver W. Muelder passed away on April 11, 1941 after a long illness. He was born in Peoria, Illinois, on June 9, 1912.

He attended the Public Schools in San Jose, Illinois, Burlington, Iowa, and Minonk, Illinois. After graduation from the Kenosha, Wisconsin, High School, he attended Berea College, Berea, Kentucky, receiving an A. B. degree in 1935. Continuing his studies he was awarded the Master of Science degree by the University of Wisconsin where he did his graduate work in Chemistry.

He was appointed instructor in Chemistry at Coe College, a position he held until failing health forced him to relinquish his duties and return to his home in Kenosha, Wisconsin.

His stay in Iowa was quite brief but in that time, he made his presence a valuable contribution to his associates and to the students with whom he came in contact.

Ben H. Peterson
Coe College, Cedar Rapids, Ia.



MARIA M. ROBERTS
1867—1942

On April 12, 1942 at Ames, Iowa, occurred the death of Maria M. Roberts, long time member of the Iowa Academy of Science and for 51 years closely associated with the teaching and progress of Mathematics in this state.

The essential facts of her life history were recorded by Dean Roberts herself at the request of her friends at the time of her fiftieth class reunion. Concerning her birth place she wrote: "I always give the date and place of my birth as June 29, 1867, Dunlap, Iowa, but as a matter of fact the Northwestern Railway completed construction across Iowa that summer, and the town of Dunlap and I were born about the same time in the northeast corner of Harrison County".

Her father came to Iowa in 1857 from Connecticut, traveling by covered wagon from Iowa City, which was the western end of the Rock Island railroad. Iowa land was then selling at $1.25 an acre. In due time Mr. Roberts owned an Iowa farm and was one of the pioneers in accepting improved farming methods.

Her mother, Ellen Rogers, came from Michigan to Clinton County as a young girl, moving to Harrison County when she was sixteen. She taught school there during the war and was married to Mr. Roberts in 1866 after his return from four years of service in the Civil War. Maria was the eldest child of this union. She wrote of her home with deep appreciation, saying, "I have always felt that I was most fortunate in being surrounded with a delightful home life. Both my father and mother were great readers; by reading, and particularly by *thinking,* they became truly cultured people."

Maria attended country school then went to the Dunlap high school, being graduated when she was 17. Upon the advice of a neighbor Mr. Roberts decided to give his daughter a year of college at Ames. To provide the necessary $180.00 for expenses was a big problem but what a high dividend that investment has paid in service to the State of Iowa.

One year of college was followed by three others financed by rural school teaching in the "long vacations". Upon graduation in 1890 Maria Roberts was elected to teach in the then new high school in North Des Moines. In the meantime she consented to fill a sudden vacancy in the fourth grade in Des Moines, but before she had had two weeks of experience in that work she was offered a position at Iowa State College. This offer came to her from Professor Stanton by way of the private telephone wire which then connected the college with Des Moines. Because Maria had never used a telephone this conversation with Professor Stanton was by proxy. As a result of this three way conversation Miss Roberts was assured an instructorship in Mathematics at Iowa State College beginning February 1891 at a salary of $400.00 to be increased by $75.00 if she acted as assistant to the preceptress. Her following promotion to assistant professor, to associate professor, to full professor of Mathematics (1913), to acting Head of the Mathematics department, then to Head, then to Dean of the Junior College — gave official recognition to the success of a remarkable woman, — a truly great teacher and executive.

It was a matter of regret to Miss Roberts that she was unable to take the time and money for a doctorate. She did graduate work several summers at Cornell University and the University of Chicago and kept contact with the progress of science by frequent attendance at scientific meetings.

She and her colleague, Miss Julia Colpitts, wrote a very favorably received textbook in Analytic Geometry.

She was a member of the Mathematics Association of America, the American Mathematical Society, Iowa Academy of Science, American Association of University Women, Sigma Delta Epsilon, Pi Mu Epsilon, Phi Kappa Phi, Mortar Board, P. E. O. and Pi Beta Phi.

When she retired from executive work as Dean of Junior College, Miss Roberts took charge of the loan funds of Iowa State College, a position in which she continued to render vital service to the youth of the college. After the death of Miss Colpitts she started with a generous gift the Julia Colpitts loan fund.

At the time of her fiftieth class reunion the college conferred upon Dean Roberts the honorary Doctor of Law degree. At the same commencement her portrait was presented to the college by her many friends. One of the dormitories for women on the campus was named Roberts Hall in her honor. She was given the Chicago Alumni Service award as one of those whose contribution to the college had merited outstanding recognition. There is a Maria Roberts loan fund to which she gave generously, and to which her many friends are making contributions in her memory.

In her student days Miss Roberts served as the first president of the college Y. W. C. A. Her active interest in the work of the organization continued throughout her life. She served many years on its advisory board and gave generously of her time and money to its support. She was an active member of the Congregational Church of Ames.

As a capable, fair, far-seeing executive she made a lasting contribution to education in this state. As a great teacher she inspired thousands of young men and women with a deep respect for thoroughness and truth, she stimulated them to undertake the high adventures of hard work and straight thinking, she motivated them to live on a high plane of eternal values, she gave to each the precious gift of a wise, loyal, helpful, never-to-be-forgotten friend.

She was known personally to many members of the Iowa Academy. To these her death is a sad loss. In the policies of a great college, in the respect and affection of her colleagues and students her influence carries on. Maria M. Roberts has a place among the outstanding educators of her day.

Gertrude A. Herr
Helen F. Smith

PAPERS PRESENTED
AT THE
FIFTY-SIXTH ANNUAL MEETING

SCIENCE IN A CHANGING WORLD

ROY A. NELSON

This year Iowa Wesleyan College celebrates the Centennial Anniversary of its founding and the Iowa Academy of Science pays tribute to that institution by holding its Fifty-sixth Annual meeting here in Mount Pleasant. Scarcely a decade after the first permanent settlers had taken up their abode in what later became the state of Iowa, this institution had its beginnings. It ranks among the oldest institutions of higher learning west of the Mississippi River.

As the early settlers extended the frontiers westward and developed the natural resources of these fertile prairies, equally courageous and farseeing pioneers established institutions of higher learning where the children of these early settlers could receive training so that they could take their places among the leaders in the development of this country.

In the field of science, Iowa has made contributions equalled by very few states in the Union. In a study of Iowa's Contribution to American Men of Science, presented before this Academy in 1939, Zabel found from a study of the birth places and the institutions where scientists received their training, that two out of every twenty-one North American scientists are or were Iowans. His concluding statement emphasizes this fact. "Iowa, long proud of her tall corn, her fertile rolling prairies and her well-managed farms has been overlooking what may well be an object of statewide pride, as it is a most important contribution to our times, the work of her scientists."[1]

In the field of science Iowa Wesleyan has made significant contributions through the century of its existence. This institution and other small colleges of the state have made their greatest contribution to the development of science in this country, in the young men and women they have prepared for the graduate schools by giving them their basic training in the sciences as an important part of their liberal arts education.

As the representative of the Iowa Academy of Science, I want to extend to Iowa Wesleyan College the best wishes of this Academy on the occasion of your Centennial Anniversary.

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[1] Zabel, H. E. 1939. Iowa's Contribution to American Men of Science. Proc. Iowa. Acad. Sci. 46:71-87.

This, the fifty-sixth annual meeting of the Iowa Academy of Science, is being held in one of the most critical periods of American history. It is well for us to consider what influence the sciences have had in the development of our civilization and also what contributions science will or may make in the future. I do not mean that we can predict what new discoveries will be made but rather how scientific reasoning and the application of scientific knowledge may be used to the fullest extent.

During the time this organization has been in existence, greater progress has been made in the application of scientific principles than in any similar period of human history. In the development of the airplane, the automobile, high speed trains and fast steamships, we have means of transportation undreamed of fifty years ago. To cross this continent now is just a matter of hours instead of days. Even the remotest parts of the world may be reached in a comparatively short time. The developments in communication have been even more significant. Until the development of the telegraph, the telephone and the radio, communication could be no faster than the means of transportation. Now messages, news and music may be sent around the world in a fraction of a second. The great strides made in these two fields should have tied the peoples of the earth closer together. Instead, during the period in which these developments were taking place, we have had the two most devastating wars of all history. These two developments that have come from science along with the others are the nucleus about which modern armies are organized. Is it any wonder, then, that some people question the value of science to society and even suggest that the destruction wrought in a "scientific war" may outweigh the good that comes from science during times of peace? During a struggle such as we are now engaged in, the scientists have several important functions. They are doing essential research on one hand to make our offensive forces more effective and on the other hand to develop defensive methods that make the enemies' offensive less effective. The scientists are called upon to do many other important jobs, such as solve problems that have to do with production of war equipment, problems of health of our armed forces, treatment and care of the injured, the development of synthetic and substitute products where the supply from natural sources is not adequate or no longer available. Another important function the teachers of science have been called upon to perform is to help train the personnel needed to effectively operate the complicated machines used in a modern war.

Not only do the armed forces need technically trained men but there is need for scores of thousands of young men who have had sufficient training in basic mathematics and science, so that the army and navy can give them technical instruction. This has forced upon us a realization of one of the deficiencies of the educational system, the inadequacy of basic training in science and mathematics. We live in a country where the developments of science have been available to a larger proportion of our people than in any other country and yet, as the uses of science for the benefit of mankind have increased, we have decreased the training given in basic science in our educational system. It has taken a serious situation such as we now face to impress this fact upon us.

Most of the information we have obtained about atoms and molecules has come from a study of their reactions in what the physicist calls the "excited state". It is only when atoms are in this excited state under the influence of electric fields or high temperature that the spectrum, characteristic of the particular atom, is emitted. From a study of wave lengths of the light produced when hydrogen is in the excited state Bohr developed his theory of the atom. Perhaps in a somewhat similar way the "excited state" of the world today may show some fundamental deficiencies in our institutions, such as the educational systems, that are not evident during more normal conditions.

Science which has given the world the submarine, the airplane, and the motorized equipment which are being used so effectively in modern war, has also given us synthetic rubber, synthetic fuels, plastics and fertilizers which should remove some of the causes of wars—the needs for natural resources, the pressure of population and shortage of foods. The applications of science should make it possible to establish a just and lasting peace if the same effort were to be applied that is found to be necessary in promoting a war. We must recognize the fact that the scientific idea has been a very significant factor in influencing the trend of world affairs for the last century and will be of still more importance in the years to come. In the sciences we have a body of knowledge that is unique in several respects. It is the only large body of knowledge that is both sequential and cumulative. It is universal and knows no national boundaries. A nation may establish its own social order of religion, different from that of other countries, but if any advances are made in science in that country they will be a contribution to a larger body of knowledge. In the fine arts, masterpieces are of no greater merit than those produced centuries ago. Science, on the other hand, moves in only one direction—that is, to make progress. The rate of progress may be accelerated or slowed down but there can be no regression. Scientific thought is a dominating force that must be taken into account. It, in itself, may be neither for good nor evil, its ultimate value to humanity may depend only in the way it is directed. We who live in a democracy have the privilege of choosing our own destiny. We may not choose wisely but we still have the right to make the choice.

When science is viewed in its larger aspect, it is not only its applications, important and far reaching as they are, that must be considered, but also the very nature of science itself must be the underlying basis for evaluation of its advancement. Why is it that this greatest achievement of human thought has been able to advance so rapidly in the last three centuries while the advances in the other fields have been so limited in comparison? To find an answer to this question one must consider both the nature of science itself and the methods used in this field to extend its frontiers further into the unknown.

In trying to understand nature, the scientist is continually searching for reality, to use facts to determine the validity of theories. What reality is may be a philosophic question and perhaps the formulation of the meaning of the term should be left to the philosopher. From a scientist's point of view we may consider reality, as that which is subject to experimental observation and verification. Scientific thought and knowledge must be subject to mathematical formulation. Not all branches of science are subject to the same degree of mathematical formulation at the present time. However, the possibility of such a formulation is an inherent characteristic of scientific reasoning. Mathematics has been characterized as the queen of the sciences. This is certainly true in the sense that it provides the method of reasoning that must be used to understand scientific thought, or that must be followed to make advances in any of the sciences.

Freedom of expression is the essence of science as well as democracy. A nation may so control the education of the youth of that country that their thought processes will be directed toward certain social and religious doctrines desired by their leaders. Such regimentation is impossible in science training. The only control possible in this field of learning would be to eliminate it or limit the amount of science taught in the schools. Such a nation would soon decay in competition with other nations in a world in which all modern livelihood and contemporary life depends upon a knowledge of nature acquired through science. One country may develop its religion, culture or social order more or less independently of what may be taking place in other lands but no one group or nation can develop its own science system.

If our civilization is to endure and free people are to remain free, then the utmost use must be made of the developments in the field of science to bring about a successful end to the struggle that now envolves nearly all people of this earth. Scientists will face an equally important task after the war in making use of their training and knowledge in the reconstruction period. To made use of the applications of science for the betterment of mankind will not be sufficient if we are to have an enduring peace. The logical reasoning that is inherent in science must be used to solve problems that face a troubled world. In establishing a social and political order that will permit an unfettered development of civilized life will require that men and women trained in science take an active part in shaping the future of human institutions. They are the only group schooled in the methods of science and are best qualified to evaluate the significance of the scientific idea as a great force in directing man's destiny.

Many people believed that the battle for independent thought and freedom of growth and expression had been won at the close of the First World War. We now realize that this was just an illusion and that the idealistic attempts to solve world problems end in failure unless that idealism is tempered with realism. New discoveries will open new potentialities for good or evil depending on how they are directed. Their proper use demands an understanding of their implications and how they may best serve society.

We should insist that the youth of this country be given more basic training in the sciences as a part of our educational system. It is only through education which includes science training that we can have an enlightened nation which will see to it that freedom of thought and interchange of knowledge and opinions will not cease to be one of man's greatest privileges.

Cornell College
Mount Vernon, Iowa

NEW LIGHT ON INTELLIGENCE

GEORGE D. STODDARD

I. SOME CURRENT ISSUES

Discussions of the meaning of intelligence frequently begin with attempts to separate heredity from environment, or nature from nurture. Such studies can be carried out only in a population in which control can be exercised over the two sets of factors. The control of hereditary factors increases as we go from unrelated children to siblings to twins. When we think of the individual child, we must recognize at once that he is a product of nature and nurture. It is not feasible to assume either that the human organism can develop independently of its genetic basis or that any set of factors can be completely gene-controlled. This point I have developed elsewhere (Stoddard, 1939):

> "It is certainly true that the talented inherit appropriate potentialities. The very fact that they are talented indicates, in a circular fashion, that they could have been talented. But this does not say that their parents were talented or that their children will be talented; nor does it indicate what proportion of their talent was ascribable to hereditary factors.
>
> "Talents can ordinarily be hung on some framework as follows:
>
> 1. Hereditary factors (those carried in the genes).
> 2. Constitutional factors (characterizing a specific individual, but not carried in genes and not a resultant from social pressures; *e. g.*, prenatal hemorrhages, endocrinal relationships).
> 3. Environmental factors (nutrition, stimulation, and education).
>
> "I should regard intelligence as always an emergent from factors 1, 2, and 3 above, with full recognition that any one of these factors may vary from almost negligible to almost crucial strengths. Thus any gene-carried tendency toward microcephaly will result in feeble-mindedness regardless of the pressures of 2 and 3, but potential genius may be unlucky in 2 and pathologically depressed in 3 so as never to emerge in the individual. Even as we go toward the central tendencies of the distributions of these factors, we get results that are complex, unpredictable, and perhaps truly indeterminate.
>
> "Of course neither feeble-mindedness nor genius can be controlled by paying attention only to the extremes of a population distribution. H. S. Jennings estimates that, if one were to assume that a single gene could carry a feeble-mindedness taint, there are thirty times as many individuals with

> this gene as there are feeble-minded persons. Thus, even to a geneticist, the mass of feeble-minded, as well as of genius, arises out of the mass of the people. Nevertheless the segregation of the feeble-minded, the criminal, the insane, on a combination of genetic and social grounds, is one procedure on which we may all agree. It cannot, of itself, solve our great social problems down through the generations, but it is humane and helpful.
>
> "Here again, Jennings, who is a distinguished Johns Hopkins zoologist, points to the intricate nature of the problem. To quote:
>
> " 'Under certain conditions, a given set of genes may produce a defective individual; under other conditions, a normal one. The defectiveness of the individuals could therefore be prevented either by starting them with a different set of genes, or by changing the environment in which they develop. In the fruit fly, defectiveness of a certain gene produces under ordinary conditions an abnormal structure of the abdomen. But if the individuals are kept in a dry atmosphere, the abnormality does not appear. A change of environment has prevented the effects of a defective gene. . . .Essentially the same in general principle is the effect of education, training and the like, in changing the behavior that would without it result from the genes present in the individual. In some of these matters the effects of genes and environment are inextricably intermingled. Behavior is bound to be relative to environment; it cannot be dealt with as dependent on genes alone'. (Jennings, 1930)
>
> "It may be said that until comparatively recently the euthenic approaches to these human problems seemed almost as hopeless as the genetic. There was much to justify the old Biblical morality about the sins of the fathers being passed on to the sons, generation after generation. The poor, the unlettered, the stupid, the starved remained in this primitive state so consistently, so downright wilfully, that it appeared plausible to postulate gene-carried factors, strong in their enduring ability to produce weaklings.
>
> "But there have been straws in a counter-wind, and some of them have blown from over the rolling plains of Iowa." (p. 490-491)

Since the intelligence quotient (IQ) is a ratio, the fixity of this measure of brightness, could be established only in terms of a deceleration in mental age for some children (the dull), an acceleration in mental age for others (the bright), and a constant growth in mental age for still others (the average). Any attempt to associate a concept of fixity *in a ratio* to a set of gene-controlled factors will give us an idea of the complications involved. The mental age itself is derived from simple verbal tests in which the chief factors are vocabulary, memory, reading comprehension, and problem solving—all measures which are derived not only from the quality and maturity of a child's nervous system but from cultural conditions. The crudeness of the particular measures can be sensed from a brief quotation (Stoddard, 1941):

> "In reality the IQ concept is not simple. Let us take a quick look at the numerator, or mental age, as determined, let us say, by the 1937 Stanford Revision. Since at this point no controversial issues are involved, time can be saved by a simple enumeration of the considerations given weight in the selection of test-items:
>
> (1) increase in percentage passing with increase in chronological age
> (2) a correlation of the per cent passing an item with mental ages from the 1916 revision, or with a composite total score
> (3) ease of administration and scoring
> (4) appeal to the child
> (5) brevity
> (6) lack of sex imbalance.
>
> "All these variously employed and pragmatically weighted criteria were taken in conjunction with the tacit understanding that, for a sampling of American-born white children, each test and the composite should be related to pupil achievement in standard subject matter. They do not, however, throw much light on the meaning of intelligence, for we come out with the old tests familiar to Binet or to the Army workers: opposites, comprehension, analogies, vocabulary, similarities and differences, completions, absurdities, memorizing, etc." (p. 250-251)

II. Some Recent Studies

Typical of recent findings on the effect of nursery school attendance on the IQ is the work of Wellman (1940). For 652 children in attendance at the Iowa preschool laboratories, the mean initial IQ was 117, and the average gain during the year of preschool attendance was 7 points. The distribution of change is given below:

Points of Changes	Number of Children	Points of Changes	Number of Children
+43– +47	1	– 3– – 7	69
+38– +42	1	– 8– –12	31
+33– +37	9	–13– –17	12
+28– +32	19	–18– –22	6
+23– +27	24	–23– –27	7
+18– +22	55	–28– –32	0
+13– +17	72	–32– –37	1
+ 8– +12	108		
+ 3– + 7	124	Total	652
– 2– + 2	113		

For two years of attendance (based on 228 cases) the total net gain was 10 points; there was no further net gain for longer attendance.

In a follow-up study, Virginia Messenger compared nursery school and non-nursery school children in Iowa City and Stillwater, Oklahoma (Messenger, 1940). Altogether she had about 100 children available in the two situations. The study was carried on over a two-year period, with some interim measurements at the end of the first year. Many of the control children were on a nursery school waiting list; as a group they were comparable to the children entering nursery school, and their families were of the same socioeconomic status. The groups under comparison were fairly stable in both situations. In Iowa City, 20 out of 25 nursery school and 22 of 27 non-nursery school children remained in the study for a two-year period; in Stillwater, 16 of the 26 nursery school and 17 of the 27 non-nursery school children were available for the two-year period. At the beginning of the study, in the fall of 1937, IQ's for the Iowa City nursery school children ranged from 100 to 148, with a mean of 119; for the non-nursery school children, the range was from 100 to 154, with a mean of 116. In the initial testing at Stillwater, the nursery school children ranged in IQ from 95 to 154, with a mean of 122; the non-nursery school children ranged from IQ 97 to 142, with a mean of 118. These slight differences in initial ability were taken into account in the method of covariance which was employed in analyzing the data. Children under 3½ years of age were given the Kuhlmann Revision, and those above this age, the original Stanford Revision. The Stanford Revision was the final test used in all cases. All tests were given by experienced persons.

At the end of the first year of nursery school experience there was a gain of 10 points in the Iowa City situation, and of 7 points in Stillwater. During the second year, the nursery school children failed to add to their gains. At the end of the second year, the gain was 8 points in Iowa City; in Stillwater, the total two-year gain was 3 points. The entire picture for the non-nursery school group is a maintenance of the initial IQ status. The final differences between the nursery school children and non-nursery school children, both at Iowa City and Stillwater, are significant at the 1 per cent level of confidence.

In summing up the Iowa studies, together with reports from six other institutions, we have found that no nursery school reported a loss on the retesting of children who had attended nursery schools for a period of from 6 months to 3 years. In some cases the gain was substantial; in others it was not statistically significant. To quote (Stoddard, 1940):

> "The general picture is one of gain. How can one explain this? There are two possible explanations. The first is that there exists a constant error in the standardization of the tests at these ages. Such an error would have to run through the 1916 Stanford Revision, the Kuhlmann Revision, the Minnesota preschool tests, the Merrill-Palmer tests and the 1937 Stanford Revision. If such an error existed, very likely it would have been found long ago, and appropriate adjustments made in the latest revisions. There is another alternate; namely, some nursery schools and comparable homes, of the high quality found when careful matching is done with nursery-school children, are really exerting a favorable effect upon mental development. In some cases such a group of homes may do about as well as the nursery school; in other situations, the nursery school is able to maintain a superiority. (In Iowa City, for example, the nursery-school children made their gains from fall to spring, that is, while attending the nursery school).
>
> "There is no mysterious advantage accruing to the nursery school as such. In homes that can provide their children with good play and reading facilities, with good opportunities for exploration, companionship and language, stimulation should equal that in the nursery school." (p. 230-231)

As we move up to older children in elementary schools there may be, under certain conditions, a similar gain; in any case, we always find a tremendous amount of variation in IQ on remeasurement. This is shown in the work of R. L. Thorndike (Thorndike, 1940). Below is tabulated the change in IQ on retesting over a period of several years. The IQ's are based on individual testing of 1,167 pupils in three well-known elementary schools in New York City.

Change in IQ	Number of Cases	Change in IQ	Number of Cases
50	2	0	176
45	3	− 5	166
40	7	−10	123
35	11	−15	80
30	15	−20	21
25	45	−25	8
20	60	−30	4
15	105	−35	6
10	154	−40	1
5	179	−45	1

In two of the schools mentioned above there was not a significant gain in IQ, but in one the mean gain on retesting was 6 points. On the whole, it will be seen from this tabulation that there is a change of 20 IQ points or more in 16 per cent of the cases.

In a study carried on by Harold M. Skeels and Marie Skodak, it was found that illegitimate children, if placed early in good foster homes, do very well mentally; in fact they exceed the average status of children for the country as a whole. These results are tabulated below:

IQ DISTRIBUTION FOR FOSTER CHILDREN IN CONTINUOUS STUDY*

IQ	First Test	Second Test	Third Test
155-159	0	0	1
150-154	1	1	0
145-149	0	2	2
140-144	5	1	3
135-139	6	3	3
130-134	6	9	3
125-129	20	7	17
120-124	19	11	8
115-119	20	11	21
110-114	17	31	25
105-109	13	21	21
100-104	12	20	15
95- 99	12	8	10
90- 94	3	9	4
85- 89	2	4	5
80- 84	3	1	1
Number	139	139	139
Mean	116	112	113
Median	116	111	112
Standard Deviation	14	13	14
Mean Age	2 yrs., 3 mos.	4 yrs., 4 mos.	7 yrs., 1 mo.

*Data from Skodak in 1942

It will be noted that there are no feeble-minded children in this group and very few children who could be classified as below average. On the other hand, there are several bright children and the whole picture of mental development is favorable.

Some years ago, under Station auspices, an experimental nursery school was set up in the Iowa Soldiers' Orphans' Home at Davenport. Two groups of preschool children were matched; one group was placed in the new school, while the other was allowed to carry on without scholastic attention (Skeels, 1988). The study shows that 3 children attended the preschool 104 weeks or more; 18 children attended the preschool 52 to 103 weeks; 14 children attended the preschool 26 to 51 weeks; 24 children attended the preschool 1 to 25 weeks.

By the end of 4 months there was some deviation in the general IQ patterns. In the period of residence from 200 to 399 days, the preschool children gained 4 points in IQ, while the control group lost 1 point. For 400 or more days of residence, the preschool children gained 5 IQ points and the control group lost 5. For children under 80 IQ, preschool attendance did not make much difference. However, for those children whose IQ's were 80 or above, it was found that, with 400 days of residence, the preschool children maintained their status, while the control children lost 16 IQ points. A slight regressive tendency cannot explain the differential shift in the matched groups of children; the reliability of the tests was the same for both groups. Similarly, in vocabulary, general information, social competence, personal adjustment, and motor achievement, the experimental group tended to depart increasingly from the control, the departures being favorable to the preschool group.

Subsequently, Edna Lee Pegram (1940) in a master's thesis re-analyzed the Binet IQ changes in the Davenport orphanage children, utilizing the statistical methods of covariance. She arrived at these conclusions:

> "The control children who had been in residence 400 to 599 days and the preschool group of comparable residence were 4.9 IQ points apart in adjusted final mean in favor of the preschool children, and the control children who had been in residence over 600 days were 18.6 points lower than the preschool group with longest residence.
>
> "The results which were obtained in the reanalysis were in general trend similar to those obtained in the original study. In some comparisons the gains of the preschool group and the losses of the control group were larger when reevaluated in terms of individuals."

III. Some Implications

We may wonder why there has been so much controversy about findings of this type. It would appear that there is no need for conflict. Hereditary factors are linked with cultural and social phenomena in a complex manner: as yet we know very little about the organic bridge. We know certainly that vocabulary is not inherited as such, while the quality of the growing nervous system is in part inherited. We have to differentiate between potentiality and actual delivered mental power, for it is only the latter that can be measured by mental testing. We know too that the validity of the intelligence quotient does not depend upon its constancy. If children do go up and down in their relative mental ability, this is something a test should discover and measure. Clearly a test which failed to be responsive to such changes would not itself be a reliable or valid measure.

It is possible, too, that test makers and test publishers become conservative because they have a large vested interest in the enterprise. For a long time, test makers, buttressed by minor psychological studies, were convinced that only slight changes could occur in IQ's and that these changes were only a function of test unreliability. It may be said, however, that up to the time of the major Iowa studies the essential data were lacking; no one else, for example, had followed through in a longitudinal study of what happens to presumably low-grade children, prior to the time of the Skeels-Skodak study.

That there are more than theoretical outcomes to this type of work is indicated by the concern of state administrations for the welfare of dependent children. If one holds strongly to the hereditarian view, this will begin to show up in social administration. A comparison between the recommendations in two states, Massachusetts and Iowa, indicates this practical outcome. In Massachusetts:

> "It is also desirable to investigate thoroughly the hereditary and social background of the child. Special attention should be given to the search for evidence of mental disease, intellectual inadequacy, severe emotional instability, general economic incompetency and shiftlessness, pronounced alcoholism, epilepsy, diabetes, syphilis, hemophilia, exposure to tuberculosis and congenital abnormalities present in other members of the family but recessive in the child." (Spencer, p. 15, 1935).

In Iowa:

> "Our placement policy, then, is based on the belief that any child who is born without physical defects or abnormalities has every possibility of developing normally, provided he is given adequate physical care, sufficient mental stimulation, and the emotional security that comes from feeling that he belongs and matters to some one.
>
> "Barring physical and organic defects a child in an adequate home and community will develop at least normal intelligence. The same child, placed in an inferior home and given few outside experiences, will probably not reach as high a level as he would under the more favorable circumstances.

> "His traits of character and personality will be those called forth by the environment and by the example you set. If he has a bad temper, it will be because he has learned he can get what he wants by it, not because his great-uncle Ned on his mother's side had one. If he enjoys music, it will be because someone has made it a pleasurable experience for him, not because his grandmother played remarkably well on the parlor organ. You will be surprised to find your own family's traits, good and bad, appearing in a foster child.
>
> "However, we have no intention of discounting the importance of heredity or of suggesting that all children are born with equal potentialities for growth, either mental or physical. We do believe that all children who are medically and physically normal have a sound heredity which will permit development within the normal range. We feel that this is true for either own or foster children, whether the parents are of so-called high or low social levels.
>
> "Defective children are not placed in foster homes, no matter how excellent the social history may appear to be. For this reason it is safe to say that people adopting a child take no greater chances than those having their own children. In many ways they take less chances, since major defects such as birth injuries, physical abnormalities, and organic defects are ruled out." (Iowa Board of Control of State Institutions, 1941).

While the Massachusetts and Iowa policies outlined above are strongly opposed in principle, we need not conclude that, over the years, the two populations of children will differ from one another. I predict that a follow-up study, based on substantial samplings in these two states (preliminary evidence for the Iowa children has already been cited), will show the foster children to be above average in intelligence, character, and vocational success. Furthermore, the children of these children should assume cultural roles consistent with that of their parents or of their foster grandparents. The main divergence as between Massachusetts and Iowa children will not be found in a comparison of these samples; it will appear in the population of children rejected in Massachusetts (because of poor family history), but accepted in Iowa. These Iowa children should not depart significantly from the rest of the sampling. But illegitimate children in Massachusetts, who by the imputations *of heredity alone* are denied the privilege of foster care, will constitute an inferior crop; for reasons that may not be hereditary, they will seem to validate a hereditarian thesis. A child deprived of milk because his mother dislikes it will develop physical deficiencies that are not gene-carried.

In short, in this branch of science, as in any other, there is no need to fight, but only to find out. The time has come for a calm and concerted study of the problem of intelligence in all its practical, technical and social implications. I am happy to report that almost every child research center in the country is now proceeding along this line.

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NUTRITIONAL FACTORS IN PLANT GROWTH AND DEVELOPMENT

W. F. LOEHWING

The large number of recent publications on the physiology of plant development reflects a widespread, contemporay interest in this subject. Researches in this area deal chiefly with the effects of specific growth substances and mineral nutrients on functional and structural ontogeny. The major contributions on the physiology of growth substances have already been conveniently assembled in certain excellent monographs (36, 53, 283, 339, 424) and reviews (37, 422, 192). Recent researches on nutrition in relation to plant development have not as yet been comprehensively reviewed. Data in this field as a whole are extremely diverse, especially as they relate to the nutritional cycle of biennial and perennial crops (20, 259, 411). In typical annuals, however, certain common relationships seem to characterize the mineral, carbohydrate and protein metabolism such that a number of generalizations can be made to aid an understanding of nutrition in relation to growth despite varietal differences (142, 228, 394).

Interest for many years has centered in the metabolic transformations characterizing the transition from vegetative to reproductive activity. Data of various authors working with annuals on this phase of nutrient metabolism permit some degree of correlation because plants have commonly been cultured under greenhouse conditions which circumvent the more extreme edaphic and meteorological variables inherent in field tests. Use of relatively large populations of annuals coupled with reasonably uniform cultural conditions also give the resulting data a fairly satisfactory degree of statistical validity. A review of research on the nutrition of annuals may thus serve to assemble a widely dispersed literature and perhaps also facilitate correlation of work in this area with that on phytohormones. Recent contributions on plant development indicate a reciprocal relationship between growth substances of the hormone type with the carbohydrate, protein and mineral components of plants (5, 16, 23, 116, 130, 204, 297, 399, 408).

Growth substances are known to influence enzyme activity (39, 261, 363) and thus bring about qualitative as well ac quantitative changes in organic synthates and metabolism (93, 131). The concentration of carbohydrate and nitrogenous components also varies with the concentration of growth substances in various parts of the plant (5, 141, 252, 253, 254, 366, 390, 431, 447). The formation of growth substances is not only dependent on a supply of inorganic nutrients such as nitrogen (16) but growth substances themselves also appear able to induce differences in the content of inorganic nutrients (50, 136, 343). In fact since many of the major growth responses have already been clearly correlated with specific hormonal agents, discovery of the mechanism of interaction of these substances with nutrients in achievement of the plant's developmental potentialities constitutes a major problem in the physiology of growth.

1. THE PROBLEMS OF PLANT DEVELOPMENT

Before proceeding with a discussion of the data on physiological ontogeny, it may be helpful to outline certain attributes of plant growth as these relate to experimental techniques and interpretation of data. Studies on the physiology of plant development are complicated by the fact that, at a given time, similar organs of the growing plant are in varying stages of their developmental sequence (12, 97, 229, 342). Unlike the animal, which commonly matures as an entity, the typical plant consists of numerous, scattered growing points in the form of apical and lateral meristems. These essentially embryonic tissues give rise to a succession of new organs in a progressive sequence of time. The resulting organs exhibit quasi-independent growth (119) such that neither comparable size and age of plants as whole nor of their separate parts serve as sound criteria of development similarity (326, 355). Briefly, the various parts of a growing plant may display simultaneously the entire range of development from youth to senescence.

This variability arises in part from the fact that during growth a single plant alters its own environment in such a way that structures appearing in chronological sequence reflect a progressive ecological succession with concomitant differences in metabolism (29, 97, 200, 260). In leaves of species with an erect habit there is commonly a vertical progression from mesomorphy of mature lower leaves to comparative xeromorphy of mature upper leaves on the same stem (19, 145, 245, 395, 416, 441). A rising gradient of sap osmotic pressure seems to characterize the mature internodes of the stem (92, 383, 395, 398) which is accentuated by water shortage (145). Similarly vertical gradients of enzymes (287) hormones (97, 424) and nutrients also occur in stems. Upper stems and leaves tend to be higher in nitrogen and protein content (10, 148, 200, 274, 362, 364, 397) though this gradient depends largely on the method of sampling (260, 274). Hydrolyzable reserve carbohydrates, on the other hand, tend to exhibit a higher concentration in basal leaves and stems (29, 200, 397). Mineral nutrient ions also commonly display vertical gradients of distribution (102), such that the concentrations of calcium, sulphur and magnesium tend to be greater at lower stem levels (10, 222, 264,311), while potassium and nitrogen are highest at upper levels (325). Despite these variations of its different portions, the vegetative parts of the plant as a whole gradually shift from a state of predominant anabolism in early life to one of increasing catabolism at maturity (21, 84). Due to such variations in composition and metabolism of various plant organs, methods of culture and analysis must be carefully adapted to experimental factors concerning which information is sought. The conditions of the environment during the entire growth cycle must be accurately known and methods of sampling for tissue analyses must be highly selective.

Correlation of plant response with environment is, however, beset with certain difficulties because plants are to a considerable degree the products of their past as well as of immediate environment as shown by studies of so-called "induced" phenomena (273). The obvious structural response to the specific morphogenic stimulus of light or temperature may, for example, often occur weeks or months after application or perception of such stimuli (143, 274). Thus, the environment under which a response makes its appearance may not necessarily be that which induced it, especially if the environment has changed appreciably during growth (12, 137, 246). Such delay between perception of and response to stimulus (after-effect) is especially evident in influences of the photoperiod upon flowering and in temperature responses of vernalized seeds. There is, for instance, considerable experimental evidence that conditions of moisture (315), temperature and light prevailing during formation of the embryo while still attached to the mother sporophyte may be more important to subsequent growth of seedlings than the physical factors of the environment prevailing during and after germination (115, 174, 180, 194, 199, 290, 443, 444). Though lying beyond the scope of this review, the recent theory of phasic development of plants seeks to correlate formative response with the external factors of temperature and light. It has been demonstrated that these factors may induce qualitative shifts in metabolism and hence of development (428). The direct effect of the environment may be upon enzymatic systems and growth substances (358), but the grosser structural changes following vernalization and photoperiodic induction to a considerable degree depend upon the nutrient conditions of the plant for their full expression. Such effects of physiological induction often provide an explanation of the developmental differences frequently found among plants growing in currently comparable environments (108, 126, 234, 235, 239, 429).

Induced responses must, however, be clearly distinguished from those which are non-induced. A brief exposure to a given environmental stimulus may produce a permanent, qualitative transition as in the case of flowering under influence of day length, or merely a quantitative response which is proportional to the duration of the stimulus. The observation of Murneek (276) may be cited as an example of the latter in which he has shown that elongation in the flower stalk of *Rudbeckia* is proportional to the duration of long day stimulus. Though stem elongation in this case is dependent upon long day exposure, it ceases when plants are returned to short day. Hence, growth of the flower stalk in *Rudbeckia* is a non-induced phenomenon which stands in sharp contrast to the inductive effect of a brief exposure to long day on flowering of the same plant (220).Certain photoperiodic responses of vegetative structures such as bulbs and tubers of other plants similarly appear to be of the non-induced type (332, 448).

Up to the present time it has been customary to consider the growth cycle as comprising primarily a vegetative and reproductive phase. There has been a general tendency to regard flowering (anthesis) as the beginning of the reproductive phase. A current issue of great interest in physiological studies concerns the exact point at which the most significant metabolic changes occur in the transition from vegetative growth to flowering. Recent data indicate that the period between inception of flower primordia and bud formation rather than the period of anthesis in which fertilization occurs is the better physiological criterion of and index to the onset of reproduction (120, 216, 270, 320, 337, 356, 386, 449). The tendency of the layman to designate the obvious appearance of blossoms as the beginning of reproduction is understandable, yet such a landmark is unsatisfactory from the physiological standpoint. Though the differentiation of flower initials involves the least conspicuous of the formative changes connected with flowering, this stage is critical in development from the metabolic viewpoint. Appearance of floral primordia marks initiation of a qualitatively different type of metabolism. Many of the nutritional transitions hitherto correlated with flowering (anthesis or blossoming) actually occur much earlier, namely with origin of the flower parts (313, 331, 409). On a formative basis, flower inception characteristically also marks a transition in rate of vegetative development and elongation of the main axis or shoots of typical annuals (45, 202, 320, 393). Differences in pre-anthesis and post-anthesis physiology are also sufficiently marked to warrant these as sub-divisions of the flowering phase itself (216, 272, 320).

Further, the physiologist also finds it necessary to distinguish sharply between flowering and fruiting. The functional attributes of fruit formation differ as much from flowering as the latter differs from vegetative growth (103, 112, 220, 319). Fertilization is commonly accepted as the beginning of the fruiting phase even though pollination without gametic fusion is in many cases known to result in parthenocarpic fruits. Experimental parthenocarpy provides a convenient method of differentiating the physiology of fruit from that of seed formation.

The method of sampling and expression of data are also important (84, 86, 113, 181, 425). The constituents of the entire plant must be known in absolute amounts rather than in mere percentages in order to check the changes in total weights throughout the growth cycle (285, 289, 329, 410). A chronological record of rates of increase in separate portions of the plant provides a much clearer picture of metabolism, and these, when combined with leaf area and root volume, give a fairly clear picture of the metabolic efficiency of individual structures as well as of the plant as a whole (19). The point of the preceeding remark is perhaps best illustrated by the relation between mineral and organic constituents of the plant. Though salts continue to increase in absolute amounts throughout most of the plant's life, their percentages usually decrease because the rate of complex organic syntheses accelerates rapidly prior to maturation (73, 222, 302, 304, 309,). The record of absolute amounts of salts usually shows a progressive increase whereas percentages thereof often fall during growth of the plant. Though salt absorption eventually ceases during senescence, the percentage composition curve alone does not reveal this fact. A localized record of absolute amounts of specific inorganic ions makes compositional shifts immediately discernible in point of time and place, data which are important aids in distinguishing cause and effect. Many helpful suggestions as to metabolic efficiency are obtained by expressing composition and syntheses in terms of unit leaf weight or area (19, 362). Such a record, for example, unmistakably reveals the vertical gradient of increasing leaf dry weight per unit of surface. Photoelectric areameters now provide a more convenient method of surface determination than the older tedious planimetric measurements (147, 197, 435). Measurements of aggregate absolute weight in a large number of plants helps to minimize sampling errors and avoids the inadequacies of percentage composition (84, 410). Continuous growth records promise to clarify many as yet obscure points on developmental physiology. To insure the best results, however, such experiments must be arranged with due regard to a sequential record of the environment and localized tissue analyses in terms of actual rather than mere percentage composition throughout the growth cycle.

Certain details of technique are imposed in studies of plant development, due to the fact that scattered growing points are the active loci of hormone secretion and formative change. Plant tissues of unlike secretory function are not usually organized in the form of separate glands as in animals but are usually closely interwoven structurally. This type of organization presents experimental difficulties and often renders gross physico-chemical tissue analyses inappropriate in studies of plant development. It necessitates such highly localized sampling that use of refined procedures of micro-analysis often become necessary (19, 84, 86, 285, 289, 326, 362). Recent developments in spectographic analysis (146), histochemistry and use of artificially activated isotopes have already provided the biologist with microtechniques of great value in analysis of small samples. Root analyses are also essential to a comprehensive grasp of the metabolic characteristics of the plants as a whole, an operation which is greatly facilitated by liquid and gravel cultures from which roots are readily retrievable. Such cultures provide a substrate far more uniform in composition and more amenable than soil to control of temperature, hydrion concentration, salts, water supply, microflora and other edaphic factors. Sand and gravel cultures apparently approximate the conditions of natural soils sufficiently to make the data of such studies of value in actual agronomic practice. Inclusion of data on root composition in recent studies on growth has brought to light a number of important top-root interrelationships.

In studies of development, attention focuses largely upon formative tissues, namely upon meristematic cells from which plant structures originate. It is the task of the physiologist to identify the metabolic factors which cause the morphological differences observable among cells arising from a common meristem (392). Since changes in metabolism of initially equipotential cells arising from a meristem must precede structural differentiation, the developmental physiologist is chiefly concerned with those protoplasmic changes which underlie the contrasted growth patterns of tissues. Such protoplasmic conditions must be precisely correlated with the environmental factors which bring them about in order that the investigator may understand the complete sequence of events and be able to check his interpretations. Existing contributions of plant anatomy and morphology have already implemented the structural phase of the developmental problem but more detailed studies on metabolism and specific morphogenic inductors are needed to bridge the remaining gaps in our knowledge of the relationships between environment and plant structure. In the ensuing review, attention is given to a number of papers which aim especially to correlate form and function with nutrition.

2. WATER RELATIONSHIPS

Water content of rapidly enlarging seedlings rises to a maximum as soluble food reserves of the seed are translocated to the young shoot and root. In pot culture experiments in which the rate of water consumption can be compared with water content of tissues, it is evident that in the earlier phases of vegetative development water intake readily compensates transpiration since maximal tissue hydration occurs well before flowering (19, 216, 362). As the growing plant achieves independence by means of its own organic syntheses, rapid water absorption and protein formation become its predominant metabolic characteristics. They induce a high degree of succulence in newly formed tissues. As vegetative growth progresses and as carbohydrate components of the plant begin to increase, moisture content begins to decline slowly but progressively in all parts except young leaves and stem tips even under conditions of uniform availability of water in the substrate. At this time absorption of water and transpiration are approximately balanced even though an age factor manifests itself as a somewhat more rapid diminution of moisture in older as compared with younger leaves. Upper leaves maintain their moisture supply at the expense of lower leaves and roots, (75, 245). Reduction in moisture per unit dry weight characteristically progresses with the age of all vegetative parts even under conditions of uniform water supply (19, 71, 92, 362, 402, 441). This differential between old and younger leaves in degree of hydration or percentage moisture is associated with the emergence of a vertical gradient of increasing xermorphy as leaves mature. Fully developed leaves at upper levels exhibit lower moisture content per unit area and fresh weight (245), a fact which suggests that the meristem from which they originate is also undergoing a shift in water balance.

There is frequent reference in the literature and substantial agreement on the occurrence of marked alterations in internal water balance during flowering (19, 89, 159, 160, 187, 191, 202, 225, 226, 258, 259, 292, 306, 350, 362). Sharp division of opinion exists, however, as to the time of inception and duration of this shift which clearly indicates a significant alteration in general metabolism as well as a distinct transition from the previous slow decline in moisture characteristic of earlier vegetative growth. Some of the discrepancies on this point are attributable to methods of analysis. Most investigators have relied on measurement of percentage moisture content of tissues sometimes at rather widely separated intervals. Investigations in which daily water consumption is accurately measured (89) show a transitory but profound reduction in rate of water absorption in the period of flower bud formation. It is abrupt in onset, occurring at the time of low carbohydrate supply to the root. Water absorption rises again with subsequent increase in root carbohydrates with an accompanying improvement in the top-root ratio but water balance does not again achieve the previous levels of the vegetative phase.

A thorough investigation of water balance during growth of wheat has recently been made by Bakhuyzen (19) who also reviews the general literature on this subject. Though Bakhuyzen associates marked alteration in water balance with flowering, he states that "our data do not show at exactly what moment the loss of water from leaves, stems and ears occurs, whether at stamination or at fertilization of ovaries" of wheat grown under constant conditions in a twenty four hour day. He correlates the change in moisture with fertilization, yet his own data as well as those of other workers indicate that inception of the shift in moisture occurs prior to anthesis rather than at fertilization (45, 89, 125, 167, 356).

As flowering is approached, the moisture curve of lower leaves per unit area tends to shift in the direction of water loss in lower leaves while upper leaves may yet be gaining in unit moisture content (258, 259, 355). Lower leaves of wheat cease to gain in moisture as early as at the twentieth day, at which time floral primordia may already be found. This alteration in water content of lower leaves precedes anthesis by ten to fourteen days in wheat under optimal conditions of moisture supply. The change in gradient of the water curve in lower leaves of cereals and other plants is sometimes quite abrupt. The pre-flowering drop in moisture content is often associated with and hence a convenient index to the presence of flower primordia or young buds in many annuals (215, 216, 362, 355). On the basis of recent work, it thus appears that the initial change in the direction of lower moisture content is associated with inception of flower buds rather than with full anthesis (89, 167) as heretofore maintained by many authors.

Reduction in tissue moisture becomes more pronounced generally as flowering reaches its ascendency. This tendency results in a rise in osmotic pressure of tissue fluids due in part to concentration of residual solutes. The increase in osmotic pressure is, however, incapable of arresting the trend of progressive dehydration as shown by continuation of water loss in spite of very appreciable increments in inorganic solute concentration in the sap at this time. We cannot escape the inference that forces other than osmotic pressure play an important role in internal water balance (19, 259, 295, 362, 406). Studies on drought and cold resistance have shown the importance of hydrophilic colloids to plant survival under these adverse circumstances (106, 164, 398). The recent work of Smirnov (362) demonstrates that cell colloids are fully as important in regulation of moisture content under normal conditions of growth as they are in plant survival during drought and low temperature (340). His data show that normal vegetative growth is characterized by high colloid and high moisture content of tissues, which with high nitrogen (protein) usually produces a condition of considerable succulence in the actively growing shoot.

The increase in transpiration and depressed rate of water entry entail a drop in moisture content of cells during flowering with a comparable increase in soluble salts of the cell sap. When the concentration of soluble salts exceeds certain critical values, as it does in older leaves, there is an abrupt diminution of hydrophilic colloids accompanied by a further and commensurate drop in moisture content of these tissues. Smirnov (362) suggests that precipitation of a large portion of cell colloids at high salt concentrations is the probable underlying cause of the sudden, coincident reduction in moisture of older leaves (13, 222). It has been shown that highly hydrated protein gels are close to the precipitation point and sensitive to slight changes in hydrion and salt concentrations (13). Confirmation of Smirnov's interpretation is found in the fact that dried powders of young but fully developed leaves can regain hygroscopically almost all their original moisture when exposed to a humid atmosphere (190), whereas this is not true of old leaves high in salts. This high degree of hygroscopicity can hardly be attributed to the salts known to occur in plant tissues in view of the fact that hygroscopicity diminishes with the rise in electrolyte content of older leaves. Measurements of sap viscosity, surface tension and the hygroscopicity of dried tissues in a moist atmosphere are convenient indices of colloid content as they check well with direct measurements of tissue colloids. Hygroscopicity of dried leaf material and high colloid content are pronounced in young leaves, conditions which suggest a highly peptized state of hydrophile constituents in the intact condition (295). Smirnov's observations lead to the conclusion that increments in water retentivity of leaves due to osmotic pressures arising from water loss are more than offset by the salting out of hydrophile colloids. Inability of the latter to retain previously adsorbed water leads to a commensurate drop in tissue moisture.

The salting out of colloids by the rising concentration of electrolytes during drying seems to be in the nature of an exchange mechanism whereby previously adsorbed enzymes are liberated. Enzymes in the free form become hydrolytically active, initiating conversion of insoluble to soluble organic reserves (100). Hydrion changes during this period may also influence the course of enzyme action (132, 133). The salt effect observed during incipient drying thus involves initially the precipitation of organic colloids with a sharp reduction in their hydrophilic properties and retentivity of tissue moisture (17, 60, 125, 299, 313, 334, 348, 359, 365, 369). Subsequently, displacement of adsorbed enzymes by the rising concentration of electrolytes leads to hydrolysis of insoluble reserves. Hydrolysis of food reserves in older basal leaves is soon followed by translocation to upper and younger portions of the shoot as well as to reproductive structures. Loss of organic reserves from lower leaves seems to preclude the possibility of later restoration of organic synthesis and hence of water balance. Lower leaves consequently tend to become chlorotic, to dry and absciss. Upper leaves temporarily maintain their water and nutrient supply at the expense of those below (19, 75, 245).

As the result of accumulation of organic and inorganic solutes, a state of physiological dryness arises. Walter (415) suggests that hydrolyses by very virtue of their increase of osmotic pressures of the cell sap accentuate the effects of dehydration by creating a state of physiological dryness which accelerates the metabolic trends induced by original water losses. Briefly, the degree of effective tissue hydration can be lowered by gain in solutes without actual water loss. The resulting rise in osmotic pressures is, however, insufficient to restore normal water balance to judge from continuation of the drying process and increments in dry weight percentage throughout the phase of solute accumulation. Progressive drying leads eventually not only to an acceleration in hydrolysis of reserves but also to diminished formation of polysaccharides and proteins. There exists a great body of data sustaining the general thesis that reduction in tissue moisture operates to stimulate enzymatic hydrolyses and to impede condensation of soluble amino acids and monoses (3, 9, 22 49, 52, 65, 158, 169 184, 255, 259, 287, 288, 307, 330, 344, 345, 359, 362, 365, 369 404, 405, 415, 432, 436).

The condition of the plant in flower is one of water disbalance and general moisture insufficiency. Despite uniformity of water supply, the percentage moisture of tissues continues to fall. This fact in association with internal redistribution of water implies inadequacy of absorption by the root. Even before anthesis water loss is above the compensation level but it is further displaced by increases in transpirational surface of flowers in bloom. At this stage, the net assimilation rate (355, 392) of the plant as a whole undergoes a diminution parallel to the drop in tissue moisture (75, 76), a fact which indicates the importance of water in the developmental cycle (288). The rate of stem elongation also falls at this time (240) and development of the absciss layer in the young pedicel may become evident. Sap acidity changes also occur as water content of tissues diminishes. Acidity of tissue fluids first increases in lower leaves and eventually involves younger leaves at progressively higher levels (118). Bakhuyzen (18) states that the primary cause of death of an annual plant which has flowered is the great loss of water at the time of flowering which reduces the general assimilatory rate of the plant (240).

It would appear, however, that there are a number of other factors which contribute to the ultimate decline of typical annuals, important among which are the radical changes in internal distribution of nutrients (70, 240, 265, 266, 267, 268, 275, 362), modifications in structure of vascular tissues (75, 76, 314, 333, 360, 386, 388, 434), and reduction in the rate of absorption by the root. The unfavorable water balance in the flower phase is temporary but of such magnitude as to be critical (19) as shown by the known sensitivity of plants to slight alterations in external water supply at this stage (64, 338, 372). Alternations in internal moisture, osmotic pressures, and distribution of nutrients are the most conspicuous metabolic phenomena associated with the shift from the vegetative to the reproductive state (332, 333), yet this does not necessarily imply that they are the primary causes of reproduction (270). Flower-forming substances such as florigen and probably carotinoids play a more direct role than nutrients in the initiation of this important developmental shift (53, 85, 117, 211, 212, 213, 215, 216, 248, 269, 271, 272, 277, 280, 335, 401, 408).

The early fruiting or post-fertilization phase is characterized by a temporary restoration of water and nutrient balance due to a renewal of anabolic processes. It has been suggested that the intensity of the anabolic impulse determines whether or not the plant can overcome and survive the heavy nutrient demands of developing fruits (278). In annuals, however, the renewal of absorption and synthesis is transitory, soon giving way in vegetative parts to a final reduction in water and nutrients which terminates in senescense and death.

3. MINERAL NUTRIENTS

In so far as the present review is primarily an attempt to outline the major shifts in nutrient balance during the normal growth cycle of common annuals, no attempt is made to discuss either the specific physiological role of individual nutrient ions or the pathology of mineral malnutrition. The bibliography of the vast literature on the effects of variable nutrition has been assembled by Niklas and Hock (286). Older works on mineral nutrition have been summarized in the classical monographs by Czapek (73), Honcamp (156), Kleberger (185), and Wolff (437). We have good current and critical reviews of this subject in the Annual Reviews of Biochemistry (125, 149, 354, 367, 375), in Fortschritte der Botanik (312), and in other publications (41, 127, 135, 151, 286, 353, 361).

The mechanism of salt absorption has for many years been a subject of debate among physiologists. The earlier concept that transpiration played the major role in root absorption (109, 341) was vigorously challenged by results of numerous experiments in which no correlation could be found between the two processes (249). Hoagland and his associates have recently adduced evidence which reconciles many of the earlier apparent discrepancies The California workers present a convincing array of experimental data on the role of aerobic respiration of the root in the absorption of inorganic nutrients (152, 375, 376). They have been abundantly sustained by other workers in the thesis that salt absorption is directly dependent upon aerobic respiration of the root system (7, 8, 38, 46, 55, 59, 63, 144, 152, 164, 166, 223, 224, 225, 226, 285, 303, 312, 316, 379, 381, 385). These observations correlate well with the known benefits of soil aeration in plant growth (4, 7, 8, 57, 58, 68, 101, 186, 208, 209, 210, 249, 384, 419).

The experimental verification of the absorption of inorganic materials as a function of root respiration to a large degree improves our understanding of the plant's ability to accumulate inorganic ions against an internal concentration gradient, a process which obviously requires a sustained source of available energy. Particular significance attaches to experiments on salt absorption by excised roots and other tissues which are entirely free from the transpiration factor. Use of such materials not only permits excellent control of experimental conditions but also accurate measurement of respiratory and absorption rates. The close correlation between respiration and initial salt intake fully justifies the conclusion of a cause and effect relationship between the two processes (48, 373, 374, 377, 378, 382). Hoagland (150) points out that though initial salt absorption is not a function of transpiration, the latter process over a long period of time may be indirectly effective in so far as salts may be moved from root to shoot by the transpiration stream thereby presumably facilitating additional absorption. Neither does Hoagland overlook the role of transpiration in regulating the concentration and aeration of the soil solution in the immediate vicinity of the root system or rhizosphere.

The maintenance of aerobic respiration in the actively absorbing root is normally dependent upon a carbohydrate as well as upon oxygen supply and it would be expected that any factor interfering with the flow of these materials to the root would tend to diminish nutrient intake (70). There is now an appreciable amount of evidence showing that fluctuations in rate of absorption by roots during the course of plant development are ascribable to the alterations in oxygen and carbohydrate supply. The root is dependent upon the shoot for its carbohydrates. When these are low in roots there is not only a reduction in rate of absorption (70) but also a relative decrease in rate of root growth, such as is often found in plants under conditions of high nitrogen supply. During rapid expansion of the shoot under normal conditions of growth, it commonly appears to pre-ëmpt the major portion of the carbohydrates thus leaving the root with an inadequate supply. Fluctuations in top-root ratios at various stages of growth indicate that these two portions of the plant do not develop commensurately. Slow root enlargement and absorption are coincident with a preanthesis stage of low root carbohydrates (89). The carbon dioxide tension in the soil is known to rise as the result of root respiration and there is evidence that this diminishes absorption through changes in root permeability which involve resistance to water movement from epidermis and cortex to the xylem (198). Thus part of the beneficial effect of soil aeration is attributable to removal of carbon dioxide (198, 218, 385) even though accumulation of this gas is less critical than shortage of soil oxygen (285). Further Brewig (43, 44) reports certain significant effects of the transpiring shoot upon root permeability. His data indicate a diminution in root permeability with reduction in rate of transpiration. As a result, root permeability and water absorption tend to vary directly with transpiration. He is of the opinion that the roots of the intact plant are much more permeable than excised root systems. Hoagland (150) also stresses the need for more information on the effects of metabolism and reproduction in the shoot on the activity of root cells (33, 56, 140, 421). The work of Steward (374) indicates the necessity of an oxygen supply for salt retention as well as for absorption (19). The fact that soil aeration sometimes proves ineffective (177) or even injurious (208, 209) indicates, however, that factors other than respiration may play an important part in water and salt absorption (26, 104, 249, 384). Ulrich (400) has recently demonstrated an interesting case of buffer action in the root by means of organic acid formation. When roots absorbed cations in excess of anions carboxylic acid increased but acids disappeared if anion absorption predominated.

Under favorable growing conditions subsequent to germination, the phase of rapid vegetative enlargement in typical annuals is characterized by progressive increments in absolute amounts of inorganic elements, carbohydrates and proteins. As the increase in organic synthates accelerates, the proportion of ash on a percentage basis begins to fall even though absolute amounts of the latter may continue to rise until well toward maturity (301). Plants often tend to absorb the major portion of their total mineral supply in very early life (21, 426) and early absorption is in general in excess of current needs when the external supply is favorable. In early vegetative stages under conditions of constant supply, nitrogen, potassium and phosphorus commonly increase faster than calcium, iron, magnesium and sulphur due in part to the relative immobility of the latter group of elements within the plant (11, 28, 54, 134, 222, 321, 328, 329). With increasing age, the percentage of calcium and nitrogen tends to fall somewhat more rapidly than other elements in typical annuals such as sunflower (329), barley (289), and wheat (42, 250). It is interesting to note that when nitrogen is available both as nitrate and ammonium salts the latter may be absorbed more rapidly in early development of small grains whereas the rate of nitrate intake may reach its peak at flowering (370).

Bakhuyzen (19) points out that fertilization with inorganic salts apparently does not raise the rate of photosynthesis per unit leaf area but that the beneficial effects of fertilization result from leaf area increase (98, 123, 196). The gain in potash, phosphorus, and sulphur evidently parallels protein formation on the one hand while on the other, calcium and magnesium increases are associated with photosynthesis and dry weight gain (19).

Differentiation and growth of floral structures apparently induce a systemic change in metabolism (6), evidenced in part as a reduction rate of water and salt absorption by the roots as already noted (38, 70, 125, 243, 312, 314, 329). Recent studies of respiration in relation to salt and water absorption suggest that lowered intake is attributable to impaired root respiration (59, 170, 303). Subsidence in the rate of root respiration is most commonly due to a progressive reduction of free oxygen and accumulation of carbon dioxide in the soil atmosphere (198, 296). Under such conditions, anaerobic respiration may be initiated but it is evidently not conducive to water or nutrient absorption (152, 224). Prolonged root anaerobiosis may in certain instances even result in formation of cortical air spaces due to tissue necrosis. (237). The factor of diminished permeability of root tissues also becomes important at the time of flowering (30, 43, 44, 15, 198, 222, 383).

The percentage drop in salt content usually noted in roots prior to and during early anthesis is not wholly ascribable to increase of organic materials but represents an actual diminution in rate of salt entry. Determinations of inorganic nutrients per unit dry weight rather than percentage salt content are necessary for the immediate detection of this change in root activity (121, 410). The root at this time lapses into a state of retarded absorption of both salts and water thus accentuating tissue dehydration throughout the plant (89). Several investigators have observed that salt intake up to the time of flowering is approximately commensurate with rate of supply but that it then begins to fall off (70, 86). As the fall in water content of roots and flowering tops becomes more pronounced, there occurs a marked redistribution of salts throughout the entire plant (387). Entire shoots commence to lose an appreciable proportion of their nutrient reserves to the roots (51, 82, 83) while at the same time salts also tend to accumulate at floral loci. At this stage of growth, roots appear to be active competitors of the flower buds for the labile nutrients of the shoot despite the relatively high respiratory intensity in floral tissues (25, 195). The flowering phase in some instances is marked by a transitory excretion of inorganic nutrients which can be resorbed during the phase of renewed growth subsequent to flowering (51).

The method of sectional sampling and sequential analysis at various stages of growth, in such a manner that a comprehensive balance sheet may be maintained at all times of net assimilative gains, discloses that with the onset of reverse translocation in the reproductive phase roots become the competitors of young fruits for the soluble reserves flowing outward from the leaves (51, 60, 67). Quantitative analysis, however, shows that the sum of specific elements accumulated in the fruits plus the residues thereof in the foilage usually does not balance out to the original total of the vegetative shoot (60, 83, 250). The discrepancy has, often without actual proof, been attributed to loss by leaching and accumulation in roots. In experiments including periodic root analyses, two major trends become evident; namely, actual translocation of organic and inorganic nutrients from the shoot to the root during reproduction, and the eventual excretion by the root into the substrate of appreciable quantities of potassium, nitrogen and sometimes of phosphorus (2, 87, 153, 159, 160, 161, 163, 172, 175, 233, 301, 430). Reserve translocation of electrolytes precedes that of organic reserves (83).

In the early stage of fruit formation immediately following fertilization, there is frequently a temporary restoration of moisture and nutrient balance due to rise in water and salt absorption by the root and renewal of organic syntheses in upper leaves. Reference has frequently been made in agronomic literature to the efficacy of fertilizer placement and soil aeration just preceding or during the flowering phase (14, 15, 24, 69, 77, 79, 80, 88, 91, 94, 99, 114, 118, 176, 178, 217, 279, 281, 293, 300, 328, 329, 336, 337, 346, 445). The favorable response to such treatment is evidently ascribable to the transitory improvement of absorption and synthesis shortly after fertilization. It appears, however, that the developing fruits appropriate the major portion of the new material because translocation continues to be oriented primarily to reproductive rather than to vegetative structures. Leaves obtain little if any of the additional nitrogen as shown by experiments in which nutrient distribution is accurately followed by determination of absolute amounts in various parts of the plant at this time (19). Fruits function as nutrient sinks to such a high degree that as they continue their growth, they absorb not only the current organic and inorganic food supply but rob vegetative parts of protoplasmic constituents beyond the limits of survival. Eventually reverse or downward translocation becomes evident as the aggregate concentration of inorganic nutrients of the entire shoot falls distinctly below that of the early fruiting phase (83, 84, 250, 410). Reverse or downward translocation of potassium, nitrogen and phosphorus from shoot to root with appreciable excretion to the soil during maturation phases has been reported in a great variety of plants (82, 86, 107, 187, 210, 213, 215, 216, 277, 410). Downward transport and root excretion of nutrients has already been reviewed elsewhere by the author (210).

The nutrient relationships of developing seeds and fruits though in some respects similar to vegetative parts are nevertheless different from those of vegetative organs. Fruit enlargement is characterized by an early, rapid intake of water and nitrogen which often subsides abruptly (11, 40, 95, 139, 189, 201, 203, 205, 219, 221, 231, 249, 274, 290, 446). Under conditions of favorable supply, the mineral components of dry fruits and of seeds in general appear to vary independently of the reserves available to them from vegetative parts (226, 267). Seeds are known to be high in nitrogen, phosphorus, magnesium and potassium (81, 244, 251, 440) but comparatively low in calcium and sulphur (11, 27, 222, 347), while fruits are relatively high in potassium, calcium and phosphorus (73) as compared with vegetative organs. Fruits evidently can serve as a local nitrogen source for developing seeds (60). Vegetative parts tend to be fairly high in organic sulphur and phosphorus. Seeds and fruits on the other hand are higher in inorganic phosphorus and sulphur (188, 264). Fertilizer placement during the reproductive phase tends to increase the nitrogen, phosphorus and potassium but not the calcium content of developing ovules (241, 407, 418). Despite obvious size increments, early stages of fruit and seed development are often accompanied by temporary loss in actual dry weight which may represent not only loss of carbohydrates as a result of respiration (247), but some actual excretion of mineral elements (161).

4. PROTEINS AND CARBOHYDRATES

A. Vegetative Stage

The initial vegetative phase of growth is distinctly anabolic with a high rate of organic syntheses and absorption of mineral nutrients (202, 250, 289). The actively growing plant is high in water and nitrogen with protein and protoplasmic syntheses as the dominant nutritional feature at this stage (42, 188, 274). If dry weight and nitrogen increments during early growth are plotted graphically, the nitrogen curve commonly rises more steeply than that for dry weight, reflecting an increase in percentage of nitrogen on a dry weight basis (19, 157, 206, 242, 329, 412, 418). Nitrogen increments precede dry weight gains during the phase of most rapid enlargement, a relationship which suggests the importance of nitrogen for the production of new tissues (19, 412, 418). The rapid rise in percentage nitrogen in early growth is a common phenomenon and it has been termed "Vorauseilen des Stickstoffes" by German workers (19). High nitrogen content is associated with high moisture content and succulence of tissues (19, 29, 89, 200, 257, 260). The percentage nitrogen drops with maturity of older leaves and the appearance of upper, younger xeromorphic foliage (19).

Reference has already been made to the existence of a rising gradient of percentage nitrogen in the progression from basal to upper stems and leaves (10, 29, 105, 274), a statement which may at first seem in conflict with the well known increase in xeromorphy of the higher portions of the shoot. High nitrogen percentages of upper portions of the shoot are found when young tissues of this region are included in analyses. When comparisons are made only between fully developed basal and upper leaves, however, the latter have a lower moisture and nitrogen content per unit dry weight (19, 260, 362). We have here an instance of the necessity of comparing physiologically similar structures if erroneous inferences are to be avoided. These relationships explain the possibility of diminishing succulence of upper leaves despite the commonly observed rising gradient of nitrogen concentration in the progression from basal to upper stems and leaves.

During the vegetative phase of growth, there is an intimate connection between carbohydrates and protein synthesis. Not only are carbohydrates and nitrogen used in the synthesis of proteins, but a portion of the soluble monoses evidently provide the respiratory energy necessary for the chemical reduction of nitrates as an antecedent to protein formation. In fact in young plants, the supply of soluble sugars appears largely to condition the rate of protein synthesis (261, 262, 263, 362, 442). Obviously also the availability of oxygen is essential to the respiratory oxidation of a portion of the carbohydrates but is usually not a limiting factor in early growth as it is later. Mothes (261, 263) has shown that all conditions, such as light, photosynthesis, and open stomata, which tend to raise internal oxygen tension favor protein formation. Conversely, protein hydrolysis is accelerated by a low internal oxygen supply, and by low water content in later development as already mentioned in the preceding section on mineral nutrients.

Thus photosynthesis as a source both of carbohydrates and oxygen is closely bound up with nitrate reduction and protein synthesis. It may also be recalled that aerobic respiration in the root is essential to intake of nitrates and other inorganic ions. When the supply of carbohydrates in the root is low, nitrogen absorption and consequently protein formation in the plant are both retarded. During the later phases of active vegetative growth, the plant rapidly accumulates carbohydrate and appears to become relatively less efficient in protein than in carbohydrate elaboration (19) as shown by a rise in the carbon-nitrogen ratio (148). Due apparently to the great carbohydrate demand during expansion of the shoot, a progressively smaller portion of the carbohydrate supply reaches the root in the course of vegetative development such that the root often, if not characteristically, reaches a critically low carbohydrate supply just prior to flowering (89, 215, 216, 399). Reduction in absorptive activity of the root occurs at this time as shown by a pronounced but transitory diminution of water and salt intake (89).

The conspicuous stages in the nutrition of the vegetative plant thus comprise an initial anabolic phase in which intake of inorganic nutrients and synthesis of proteins is rapid. In the second phase, the accumulation of carbohydrates is rapid while the rate of protein synthesis gradually subsides. As flowering is approached a third or catabolic phase becomes evident in which hydrolyses of reserves begin to overbalance syntheses, and a general internal redistribution of nutrients is initiated. Though conditions of environment and nutrient supply to a considerable degree determine the exact time of the shift from predominantly anabolic to catabolic activity, the transition is characteristically associated with flowering and it is commonly initiated prior to anthesis (89).

4(b) The Flowering Stage

As previously stated, the onset of flowering is associated with a systemic change in water and mineral nutrient balance. An equally profound redistribution of organic synthates accompanies the change in inorganic nutrients at this time. Root carbohydrates, especially soluble sugars, evidently become low enough to impair salt and water absorption to such an extent that neither water nor nitrogen intake by roots appears to cover the requirements of the shoot (19, 61, 89, 187, 230, 294). Continued transpiration consequently entails progressive reduction in moisture content which in turn impairs gas exchange and initiates hydrolysis of organic reserves (260, 362). At this stage nearly three fourths of the total carbohydrate reserve of leaves may be in the soluble state which is about triple the sugar content of foliage in the vegetative phase (74, 367). Foliar respiration also falls despite the increase in soluble sugars. There is then a drop in general assimilative efficiency (19, 47, 89, 433) of the plant as a whole.

As hydrolysis of food reserves continues, leaves are gradually depleted of their organic and inorganic nutrients. These flow into the stem and accumulate in appreciable amounts at floral loci. Depletion of foliar nutrients, organic and inorganic, and reverse translocation thereof during flowering are coincident with a general subsidence in the respiratory rate of vegetative organs (35, 65, 122, 439) especially of leaves which fall to a very low respiratory level during anthesis (362). The rate of nutrient depletion accelerates as respiratory activity falls, a correlation which suggests that respiratory energy is essential to nutrient retention (19). This concept correlates with the role already ascribed to respiration in the absorption of water and salts by roots as well as with the acceleration of absorption by soil aeration (55, 57, 58, 63, 165, 208, 209). Older leaves have lower rates of respiration and evidently are lower in oxidases (284, 362). They do not regain much protein nitrogen even under adequate supply (259). Due to loss of power to synthesize proteins, senescent leaves accumulate acid amides and ammonia (285, 362). Mothes (259), however, stresses the necessity of distinguishing between the respiratory responses of young and old leaves. He points out that respiration falls more rapidly in older leaves as drying progresses.

High respiratory losses of carbohydrates during flowering are often the cause of a reduction in rate of dry weight gain and depression of protein synthesis in the plant as a whole (19, 171, 368). Decline in the rate of respiration to a considerable degree results from the impaired gas exchange accompanying progressive reduction in water content of vegetative tissues during the reproductive phase (34, 247, 417). Floral structures, on the other hand, have a high respiratory rate, a condition which may underlie accumulation of water and solutes at reproductive loci during reverse translocation (25, 195, 414). Such functional transitions precede and later continue *pari passu* with the morphological development of flower and fruit. Floral loci also become centers of auxin formation. The presence of auxins apparently favors carbohydrate accumulation (5, 390, 424).

Reduction in rate of protein synthesis has a two-fold origin, namely reduction in free internal oxygen due to subsidence in the rate of photosynthesis and reduction in respiration due to impaired entry of atmospheric oxygen associated with progressive tissue dehydration. Mothes (268) has shown the dependence of protein synthesis upon internal oxygen tension, and a reduction in rate of synthesis commensurate with decline in photosynthesis. Smirnov's data (362), in turn, show a correlation between the rates of respiration and protein synthesis in sunflower and tobacco (90, 121, 125, 128). It is consequently probable that photosynthetic oxygen favors protein formation by acceleration of aerobic oxidation of carbohydrates. Smirnov points out that in the early life of annuals, protein synthesis parallels and hence is presumably dependent upon the concentration of monose sugars. During reproduction, however, protein production ceases to be proportional to the soluble sugar content but instead parallels the foliar respiratory rate (327, 380). Thus in the vegetative phases carbohydrate supply is the controlling factor in protein synthesis while oxygen supply becomes regulatory in the reproductive phase. Smirnov adduces quantitative data in support of his contention that respiratory energy is essential to protein formation during reproduction. He points out that the common commercial practice of decapitating or "topping" tobacco plants to remove the inflorescence prevents the sharp drop in foliar rate of respiration and protein synthesis ordinarily encountered during flowering of intact plants. Exfloration and removal of fruits in tomato and cotton, like topping in tobacco, reinitiates nitrogen and water absorption (70, 266, 267, 359). There is considerable interaction among plant parts during this stage as shown by the fact that defoliation and exfloration materially alter the course of enzyme action (82, 305, 359, 362). Further evidence for the correctness of Smirnov's interpretations is found in the differences in the amounts of carboxylic acids which distinguish intact and decapitated plants. The former are high and the latter low in specific organic acids, a contrast reflecting differences in mode of respiration.

As diastatic action of starch is accelerated by incipient drying of the tissues, there is at first an accumulation of sucrose (362). As dehydration becomes more pronounced, starch hydrolysis yields increasing amounts of glucose. The starch-sucrose reaction is reversible, starch synthesis predominating when water balance is favorable but there is no reconversion of glucose to starch with moisture restoration (158). Schulze (348) reports formation of a protease activator in *Phaseolus* and *Nicotiana* at the time of flowering which is either inactivated or eliminated during the fruiting stage. Though a post-floral restoration of water balance occurs as a result of renewed carbohydrate and protein synthesis, neither they nor the moisture content rise to the pre-floral level. Other active enzymatic constituents of the flowering phase may undergo similar modifications and thus contribute to the temporarily improved water balance commonly observed in the early fruiting phase.

In addition to the foregoing functional factors influencing the water economy of the flowering shoot, there also occurs a complicating structural modification in the conductive elements (207, 241, 360, 427). The work of several investigators (183, 333, 434) reveals a subsidence in cambial activity which originates in vicinity of the floral buds and commonly extends progressively outward therefrom toward the base of the stem (318, 360). Phloem formation especially seems to be reduced and when this results in a small pedicel, fruit setting is impaired (64). This resultant impairment of conduction appears to retard the redistribution of nutrients during the period of reverse translocation. Poor mobility of calcium and inadequacy of movement thereof from leaves to reproductive loci, may also impair flower and fruit formation (222). Struckmeyer (386) finds that plants in flower, when restored to a vegetative photoperiod, recommence normal cambial activity and growth (434). Evidence of circulatory difficulties (75, 76) and inadequacy of nutrient supply in the flowering phase is found in the studies on drought sensitivity. Several investigators have found plants more susceptible to permanent injury from water shortage during flowering than at any other growth phase, a functional response which evidently results from vascular inadequacy or failure of the type reported in histological researches (338, 372).

In summary it may be stated that vegetative development is marked by rapid absorption of salts and water, rapid accumulation of carbohydrates and proteins. The respiratory and net assimilatory rates are high. During flowering, there is initiated a general trend toward reduction in water content (322, 323), respiration (362), photosynthesis (368) and rate of protein formation (260) in vegetative structures. There follows a profound hydrolysis of food reserves and a general redistribution of soluble, organic and inorganic nutrients (318, 351). At the expense of leaves and stems, foods accumulate in flower buds as their respiratory rate rises (25). Structural modifications of the stem and reduction in the absorptive activity of roots commonly leave the flowering shoot temporarily at a critically low water level. The plant is especially susceptible to drought injury at this time (338, 372), thereafter either failing to resume growth or undergoing permanent structural modification despite subsequent restoration of moisture. The systemic redistribution of nutrients and alterations in anabolic efficiency of the plant are sequential to disturbed water balance characterizing the flowering stage.

Certain nutritional changes involved in blossoming or anthesis of floral organs themselves are equally rapid but of a localized nature. Food reserves previously mobilized in the perianth and accessory floral structures are commonly translocated to the sex organs with surprising rapidity just prior to anthesis (66, 213, 214, 256, 310, 349). In terms of the floral tissues *per se,* the morphological and nutritional transformations of anthesis are very profound (291) but in terms of immediate metabolic effects on the plant these changes are local rather than systemic (66, 256, 291, 310). The nutritional aspects of typical floral gynoecia and androecia have already been discussed elsewhere (111, 168, 182, 211, 213, 214, 357, 420). Far-reaching systemic stimulation, however, results from the processes of fertilization and the ensuing grand period of fruit enlargement (278, 362).

4(c) Fruiting Phase

In a discussion of nutrition in relation to plant development, it is convenient to distinguish flower and fruit formation even though their separation may at first appear both artificial and arbitrary in light of the natural sequence of the processes (120). It may be argued that the phenomena of fruit formation are largely a progression of the processes initiated at flowering. Formatively, however, the pistil prior to pollination and fertilization usually lapses into a condition of relative stasis which commonly culminates in flower abscission in the absence of pollination. Pollination alone, however, often retards flower abscission and may stimulate rapid parthenocarpic growth of the ovary. To this the physiological stimulus of pollination is normally added that of fertilization of the ovules. Thereafter ovary and ovule enlargement is often extremely rapid due to food and water intake. The general resurgence of metabolic activity which occurs subsequent to sexual union is sufficiently profound to justify a distinction between the physiology of flowering and fruiting, particularly from the standpoint of nutrition (266, 267, 272, 362).

Fertilization of flowers serves as a systemic stimulus to renewed absorptive and anabolic activity (78, 96, 241, 278, 348, 362, 420). The root system undergoes enlargement and exhibits accelerated absorption of salts and water, frequently reabsorbing a portion if not all of the nitrogen and potassium previously excreted during flowering (51, 82, 86). After flowering, young leaves renew protein synthesis (258, 259). Transpiration subsides, respiration rises and there ensues temporarily a better water balance in all tissues. From a nutritional standpoint, the early phases of fruiting somewhat resemble those of the vegetative phase (368). Though not yet fully understood, the initiation of the vegetative cycle in developing ovules may serve as a stimulus to renewal of such activity in adjacent tissues (348). The growing ovule itself exhibits a vegetative metabolism temporarily of a parasitic character and at the expense of reserves within the parent sporophytae (19). Restoration of moisture in tissue in early fruiting phases is associated with improved respiration and renewed synthesis of proteins and higher saccharides largely by condensation of soluble products (3, 9, 158, 160, 202, 255, 404).

Developing ovaries function as centers of nutrient deposition due apparently to their high respiratory metabolism. During the phase of their most rapid enlargement, young fruits preempt incoming inorganic nutrients largely to the exclusion of vegetative parts of the shoot. In fact, in heavily fruiting types such as the tomato and cotton, the current rate of supply through the root system appears inadequate, resulting in a heavy demand upon the nutrient reserves of the vegetative organs to sustain fruit growth. The depletion of leaves especially at the base of the shoot may attain starvation levels, resulting eventually in their death and abscission before fruits have achieved maturity (266, 267). Chibnall (60) has shown the failure of pod formation in the absence of asparagine. After the major increments in fruit size have occurred, carbohydrate influx is rapid (71, 72). Fruit respiration tends to fall as enlargement subsides, followed in fleshy fruits by the color changes of the fully ripe fruit (129, 352).

Pearsall (298) has shown that stem elongation may cease temporarily during flowering and again during fruit enlargement due to food demands of these structures. Absorptive activity of the root subsides even in a favorable substrate as the carbohydrate supply from the shoot diminishes in the course of fruit growth (70, 298). Subsequently growth of roots and apical meristems also ceases as reserves are preempted by fruits (70, 240). The ensuing moisture and protein shortages appear more critical than curtailment of electrolytes in causing the senescence and ultimate death of the plant. Luxury consumption of salts can tide the plant over longer periods of electrolyte than of water shortage. The unremitting continuance of transpiration precludes accumulation of any appreciable water reserves in annuals. When nutrient and water relations of biennials, perennials and succulents are compared with those of annuals, the survival capacity of the former group during periods of enforced drought appears to depend predominantly upon superior regulation of water economy by avoidance of that degree of desiccation which prevents resumption of normal metabolism with renewal of water supply. Annuals are unable to avail themselves of water even when available due to absorptive failure of the roots after the nutrient demands of enlarging fruits become persistent and exceed certain critical magnitudes. Leaves lose the power of direct protein synthesis and the ability to reform proteins from proteolytic residues even in the presence of carbohydrates (257). Loss of potassium has also been stressed as a specific factor capable of inducing foliar senescense (173). There ensues a sudden and final upturn in percentage dry weight of shoot tissues which soon begin to manifest symptoms of senescence as their moisture content falls to progressively lower levels. The terminal stages of vegetative parts are characterized by leaching of appreciable quantities of root electrolytes into the substrate and extreme desiccation of the shoot despite some absorption of water from fruits prior to completion of the absciss layer in the pedicles (240).

Desiccation of fruits entails increased resistance to gas exchange with attendant alterations in respiration which shifts appreciably from aerobic to anaerobic (247, 417) with production of volatile hydrocarbons (40) in certain fleshy types. Tissue dehydration and lowered respiration appear to underlie subsidence of nutrient absorption of maturing fruits, an effect which is evidently also accentuated by mechanical obstacles to translocation resulting from cambial failure (386, 388). Pope (315) reports an ingenious experiment in which he shows that if desiccation of the developing barley kernel is prevented, no dormancy occurs and that it is possible to obtain seedling transplants in fifteen to twenty days after pollination.

One of the most outstanding contrasts between the maturation of vegetative structures and seeds is the difference in response to diminution of moisture. Loss of moisture in vegetative parts results in hydrolysis of organic synthates while the same condition induces condensation thereof in seeds (232, 285, 324) as shown by the rapid conversion of amino acids to proteins (391) and of sugars to starch. Young fruits and seeds are high in non-protein nitrogen which is rapidly synthesized into proteins which accumulate in the form of insoluble reserves. Proteolytic activity subsides during maturation of seeds apparently due in part to increasing resistance of the proteins to enzyme hydrolysis (317). It is apparently the formation of hydrophilic polysaccharids and proteins with considerable bound water during maturation which protects seeds and fruits against an excessive water loss comparable to that sustained by leaves and stems and thus insures survival of the reproductive structures (352). Kidd (179) points out that arrested development of the maturing seed and even delayed germination of the moist seed are due to an inhibitory partial pressure of carbon dioxide in embryo tissues which induces a state of narcosis. Carbon dioxide narcosis of seeds depresses metabolism to a state of dormancy but without destructive injury such that when moisture and oxygen are restored, the developmental processes are renewed in germination (179).

5. SUMMARY

On a nutritional basis, the post-germinative developmental cycle of typical annuals may be conveniently subdivided into four different periods. The first comprises the high absorptive-high anabolic vegetative phase of rapid water and salt intake, rapid organic syntheses, maximal water content, and generally high respiratory level. Formatively this first phase represents the expansion or enlargement of vegetative primordia. The second or flowering phase represents an alteration in metabolism which entails structural differentiation. Functionally it is a period of lowered metabolism. Compared with the anabolic phase, respiration, absorption, water content, and organic syntheses are all lower in all vegetative parts. Reverse translocation of organic and inorganic syntheses takes place from leaves and stems to flowers, fruits and roots. Formatively, this phase comprises differentiation of flower primordia, enlargement of flower buds and anthesis. The third phase is one of temporarily renewed absorption and anabolism. Formatively it is the period of early fruit development. This merges gradually into the fourth or maturation phase in which seeds and fruits ripen while vegetative organs senesce and eventually die as a result of nutrient depletion and desiccation.

The initial systemic alteration in nutrition following the typically anabolic metabolism of early vegetative growth is correlated with a paucity of root carbohydrates and a resultant diminution in absorption. A cycle of progressive tissue dehydration and translocation of reserves ensues. Though developing seeds and fruits by virtue of their higher oxidation potentials form the chief centers of nutrient accumulation, roots seem to compete with them for an appreciable portion of the soluble reserves in the early fruiting phase. The final senescence of stems and leaves is attributable to loss of water and food reserves following subsidence in respiratory activity of these structures. The food and water demand of fruits especially in heavily fruiting species exceeds the absorptive capacity of the root system which may also be largely drained of its reserves by nutrient excretion during maturation. The condition is one of inadequacy of food absorption and translocation in later stages of reproduction which is accentuated by failure of the cambium to continue production of new vascular elements. Assimilative powers of vegetative parts are lost as gas exchange is progressively impaired and oxidation potential reduced in the course of shoot dehydration.

The foregoing discussion represents an attempt to trace the major events in the nutritional ontogeny of typical herbaceous annuals but as stated in the introduction, it is not intended to convey the impression that these nutritional factors are the prime or causative agents in shaping the structural ontogeny of the plant. Under ordinary conditions of nutrition, light (138) and temperature prevailing during early growth have much to do with the number of vegetative primordia laid down and hence also with the number of leaves and nodes eventually formed by the plant (124, 371). Nutrients available during this vegetative (or vernalization phase (273) as the nomenclature of the phasic development concept designates this temperature-sensitive stage) do, however, determine the size of the vegetative organs developed under stimulus of temperature (336).

With reference to flowering, it may similarly be said that the photoperiod in conjunction with temperature rather than food determines the date and number of flower primordia (1, 53, 248). In this case also, however, the available nutrients may determine the course of growth and maturation of the reproductive organs (23, 24, 42, 155, 282, 308). In fact, on the basis of recent experiments it seems that photoperiodic induction itself may not occur in the absence of a source of carbondioxide for photosynthesis during the induction period (297). Food eventually determines the number of flowers which develop as well as the number and size of fruits which are set and mature. Considerations of the latter sort underlie the practice of repeated or late fertilizer placement since it is known that readily assimilable phosphorus and nitrogen, for example, applied in the early flowering phase may increase the number of fertile flowers and the yield of fruit. Went (423) reports the need for low night temperatures as an essential factor in setting of tomato fruits (32). Mineral deficiencies during growth may, of course, impede or prevent differentiation or development of structural primordia even under proper stimulus of temperature and photoperiod (162, 396). Inadequate nitrogen in early growth, for instance, results in smaller plants and fewer if any flowers as compared with ample nitrogen supply. Under such conditions of malnutrition the plant is incapable of normal response to light and temperature.

The primary internal response of the plant to the known morphogenic factors of the environment is probably in the production of specific growth substances and these may consequently be considered the factors which determine the developmental or qualitative phases of its ontogeny. Certain highly localized redox systems also play a part in structural differentiation (403). The quantitative expression of these phases, on the other hand, is a function of the food supply. Stated in another way, the developmental potentialities of the plant are implemented by its organic and inorganic nutrients. Under conditions of nutrient deficiency the plant may not be capable of the normal developmental response to morphogenic factors of the environment, or if it is, it may yet be incapable of causing the growth of primordia which have been differentiated. In the light of recent evidence (12, 246, 275), it appears as if nutrients must give way to growth substances or hormones as the basic factors in *development* and differentiation though they retain their primary position as factors underlying *growth* in the sense of elongation and increase in size.

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EXTRA-FLORAL NECTARIES IN BRYOPHYLLUM CALYCINUM

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Among the interesting features of *Bryophyllum calycinum* Salisb. is the occurrence of foliar embryos in the notches of the leaf (Fig. 3) which under favorable conditions will give rise to new plants. In the apices of the crenations are hydathodes (Fig. 3) whose structure has been described by Berge (1877) and Yarbrough (1932, 1934). A hydathode typically occurs at a vein ending in a leaf margin, but in *Bryophyllum calycinum* the hydathode consists of a vascular plexus surrounding an epithem which is associated with a special group of stomata on the lower side of the leaf. The cells of the epithem superficially resemble those of the foliar embryos in that they are of approximately the same size and shape and have conspicuous nuclei and dense cytoplasm.

In the summer of 1940 crystal-clear droplets (Fig. 1) were seen on the uppermost leaves and subfloral bracts of *Bryophyllum calycinum* plants flowering in the University of Iowa greenhouse. They differed from water of guttation in several ways: 1) they appeared on all parts of the leaf instead of on the crenations alone; 2) they were very sticky, sweet-tasting, and gave strong positive reactions for glucose when tested by both the Flückiger and osazone methods; 3) they remained on the leaves for several weeks whereas water of guttation seldom remains more than a few hours; 4) these droplets always appeared in plainly visible pits (Fig. 4) about two millimeters wide and half a millimeter deep. In contrast, hydathodes of *Bryophyllum* are not ordinarily visible to the naked eye unless the leaf has been cleared (Fig. 3).

The pits and droplets, which occur in the manner described, appear only during the flowering phase and have been observed in abundance on three occasions. Small Diptera were attracted by the droplets at the only instance that insects were present when the *Bryophyllum calycinum* bloomed. This appears to support the view that the droplets, while attractive to certain insects, are not the result of insect injuries. The possibility that the droplets were of traumatic origin was tested by wounding, with a sterile needle, the uppermost leaves of *Bryophyllum calycinum* plants which had not yet reached the flowering phase. Only wound tissue was formed on leaves thus treated. Leaves and bracts bearing the pits and droplets showed no evidence of wound tissue.

Pitted areas were sectioned in paraffin and stained with safranin and fast green. Lying immediately below the center of each pit

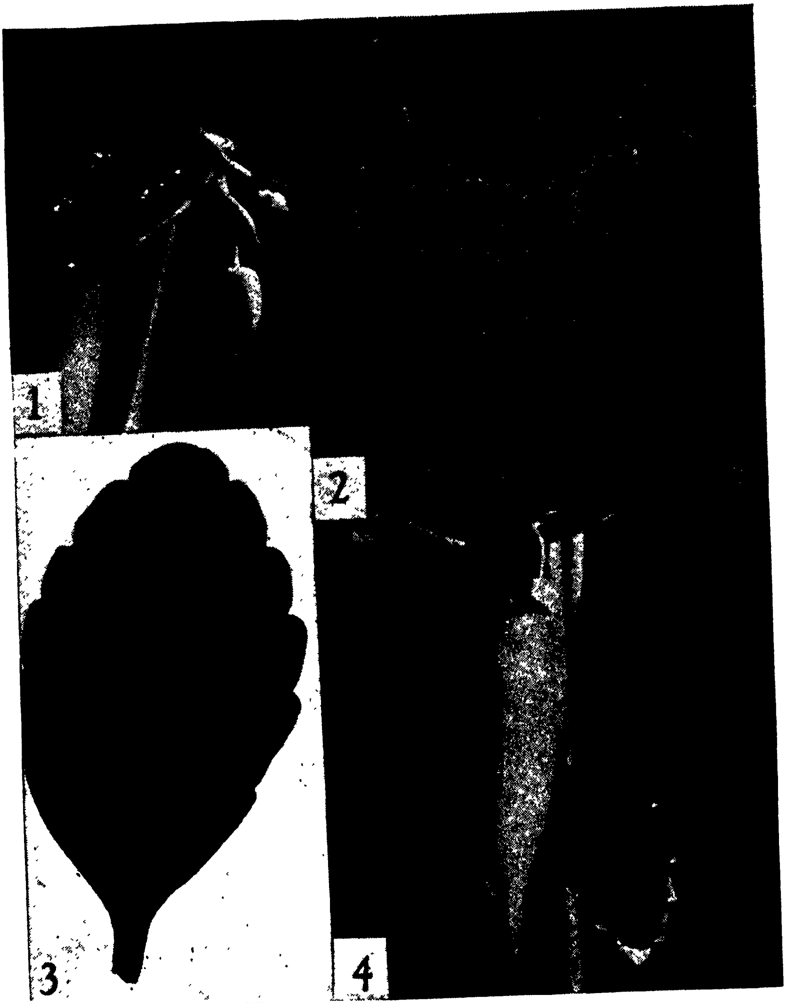

Fig. 1-4 *Bryophyllum calycinum.*—Fig. 1. Subfloral bract showing droplets secreted by nectaries. 2X.—Fig. 2. Vertical section through an extra-floral nectary. 300X.—Fig. 3. Cleared leaf showing hydathodes in the notch apices. 2X.—Fig. 4. Subfloral bract showing pits. 1X.

was a mass of glandular tissue consisting of large thin-walled cells with conspicuous nuclei (Fig. 2).

It is believed that the structures described and illustrated are not hydathodes, but are instead extra-floral nectaries. This belief is supported by the following facts:

1. It is only at the flowering phase that pits and droplets appear on the bracts and uppermost leaves.

2. The pits and droplets are not regularly associated with a vascular plexus in the crenations as are the hydathodes, but instead occur in an apparently random manner on all surfaces of the bracts and uppermost leaves.

3. The cells of the secretory tissue below the pit are typically glandular, whereas the cells of the epithem of the hydathode superficially resemble the cells of the foliar embryos.

4. The occurrence of these nectaries is apparently not associated with the presence of insects. Neither are the nectaries the result of slight mechanical injuries.

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THE DWARF LEAF OF CERCIS CANADENSIS

ROBERT B. WYLIE

For morphological investigations the selection of material is of primary importance. This is especially significant in the comparative study of leaves since these organs may have marked differences in size and structure on a given branch or on a single twig. During development they are responsive not only to environmental conditions but also to factors operating within the plant. Trees often develop diminutive foliage and insertion of the dwarf leaf on the axis may be very close to others of larger growth. This anisophylly is pronounced in many plagiotropic shoots and may also be associated with basal-apical relations. Such dwarf leaves are common in *Cercis Canadensis,* especially on secondary branches. This paper takes up the dwarf, palmate leaf of *Cercis* in comparison with its sun and shade leaves of larger growth. These results are also compared with the findings of Obaton who studied the dwarf, pinnate leaves of several species. (Obaton, F., 1922, Revue Gen. de Bot. Vol. 34). The contrasting expressions in these two types of dwarf leaves are of special interest.

Material: Three representative leaves were selected from the south side of a *Cercis* tree, about 12 feet in height, that stood in the southern border of a clump of shrubbery on a lawn in Iowa City. The tree received full sunlight most of the day and was in some degree sheltered from drying southwest winds by nearby trees and buildings.

The largest of the three leaves, and best illuminated, was third from the tip of an intermediate branch. This twig carried no dwarf foliage though the lower leaves were smaller than the upper. The two partly shaded leaves were from the terminal portion of a lower branch; the larger of these leaves was third from the tip and the smaller, the dwarf leaf, was seventh on this axis. While the dwarf leaf was shaded more than the other on this twig both were in favorable light through much of the day. These three leaves will here be referred to as "sun," "shade," and "dwarf," respectively.

At the time the leaves were collected sample areas, about 3 x 10 mm, were cut out of the lateral half of each blade at seven selected stations (Fig. 1). Four of these were distributed along the midrib from near the base towards the apex, but far enough from the center to escape the local thickening of blade near larger veins. Three stations were located nearer the margin, somewhat back from the edge, to avoid the peripheral thinning of blade. These excised portions were killed in Nawaschin's solution, imbedded in paraffin and sectioned 12 microns thick. A smaller part of each sample-area was cut transversely, and the remaining larger part was sectioned in paradermal direction, that is, parallel to the surface of the leaf. A useful stain was the Safranin-Haematoxylin combination.

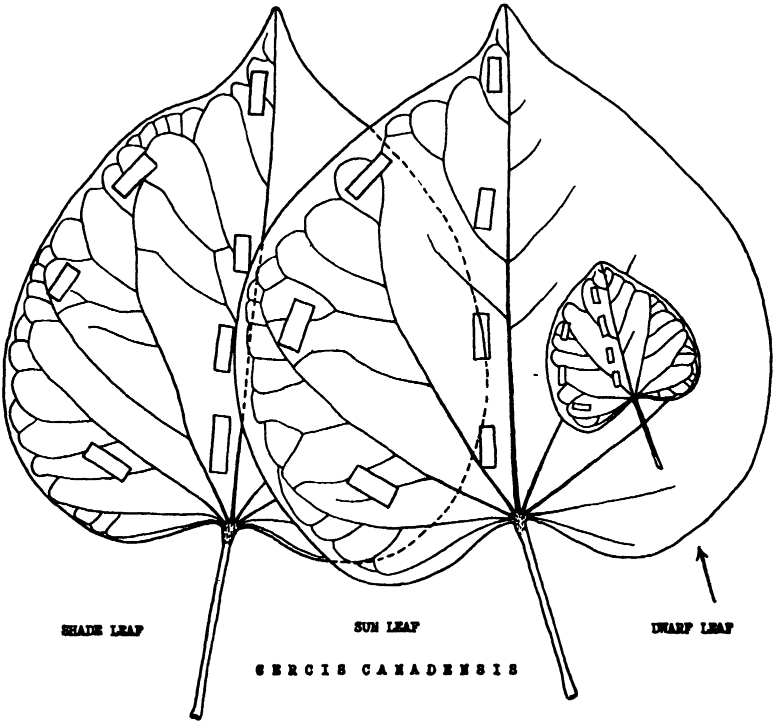

FIG. I.

These three *Cercis* leaves were surveyed both with respect to differences among the seven stations of each blade and also by comparison with one another. Micro-measurements of each sample-area were made covering (1) total thickness of blade, and of each component layer,—upper epidermis, palisade, spongy mesophyll, and lower epidermis; (2) cell size (measured in upper epidermis); (3) radial diameter of border-parenchyma; and (4) total vein-length per unit area of blade. Any figures used represent an average of ten to twenty measurements, depending upon the degree of variation. The actual areas of the blades were determined by planimeter, and extent of venation by direct linear chartometer measurement of drawings made by projection from the prepared slides.

Observations: The leaves of *Cercis* back from the tip diminish rapidly in size especially on branches of slower growth and on secondary twigs. For an axis carrying seven leaves their relative areas, from apex downward, were as 10.2, 11, 11.3, 8.4, 5, 2, and 1; for an adjacent and shorter lateral twig, with 5 leaves, the series was 11, 8.7, 5, 1.6, and 1; and for a semi-interior twig on the same branch, having four leaves, their relative areas were as 13.5, 7, 2.1, and 1.

These three selected leaves were alike in form but differed greatly in size. (fig. 1) The "sun" leaf was largest with an area of 141.3 sq. cm.; the "shade" leaf, next in size, 121.9 sq. cm.; while the "dwarf" had an area of only 12.7 sq. cm. They were similar in shape and had the same number of major veins radiating from the petiole at about the same angles. When drawings of all three leaves were made to equal size and superimposed only minor differences in outline and major venation were noted.

This is in striking contrast to Obaton's observations on the venation in dwarf leaves of *Castanea vulgaris, Ulmus campestris, Fagus sylvatica* and other lanceolate forms with pinnate venation. In the nine species that he studied there were differences in form of blade and the major lateral veins were fewer in the dwarf leaves, some having less than half the number found in normal leaves. Similar differences in pinnate leaves of other species were confirmed by field and herbarium observations in connection with this study, though these leaves have not yet been submitted to tissue analysis in this laboratory.

While outwardly alike except for size, microscopic study of sections from these *Cercis* leaves revealed considerable differences in their organization. Taking the mean of the seven stations for each leaf as a basis of comparison, thickness of blade was greatest in the sun leaf (166 μ.). It was much thicker than the shade leaf (101 μ.), which was nearly the same size and had corresponding position on its twig. Thinnest was the dwarf leaf (99.6 μ) which was seventh in series downward on its axis. These records for thickness are not in agreement with the figures given by Obaton for the dwarf pinnate leaves which he surveyed. He found they had approximately the same thickness in each case as the large leaf of the species. In five of his plants the large leaves were thicker; in the three the dwarfs were thicker and in one they had the same thickness. The sum of leaf thickness for all nine of his dwarfs was only 0.38% less than that for the sum of all the large leaves. The sun leaf of *Cercis* was about 66% thicker than the dwarf.

Comparing the values for the seven stations of each of the *Cercis* leaves there were some differences in the distribution of blade thickness. Of these reference will here be made only to total thickness. All were thickest in the medium basal region. The shade leaf was thinnest in the median sub-terminal area while the others were thinnest in the marginal region near the part with greatest width.

Epidermal thickness was greatest in the sun leaf, with shade and dwarf in the order named. While the total range in the upper epidermis was over seven microns neither the thickest nor thinnest area for any two of the leaves was found in the corresponding stations. Radial thickness of the border-parenchyma was greatest in the shade leaf and least in the dwarf, but as noted elsewhere, this layer is more nearly constant than any other of the blade.

The vertical depth of spongy mesophyll differed but little among the three *Cercis* leaves. This zone was thinnest in the shade leaf (19.18μ), while dwarf and sun had nearly the same thickness (23.15 and 23.5μ respectively), but the range for all was less than 5 microns. The palisade on the other hand was the only layer showing striking difference in amount. It was thickest in the sun leaf (113.23μ), least in the dwarf (50.μ), and only slightly thicker in the large shade leaf (56.μ). Note that the sun leaf had considerably more palisade thickness than that of the two others combined. These figures for palisade parenchyma are very different from those given by Obaton for the dwarf pinnate leaves. For his nine species he found very little difference in amount of palisade, comparing large and dwarf leaves. In one species they were equal, in another the dwarf had thicker palisade, and, for the others there were slight differences in favor of the large, sun leaf. The total palisade thickness of the large leaves for his nine species was only 1% greater than the sum of measurements for this zone in the associated dwarfs. In *Cercis* the palisade layer of the sun leaf was 126% thicker than that of the dwarf.

Total vein length per unit area was greatest in the sun leaf of *Cercis* (88.5 cm. per sq. cm.), least in the shade leaf (75.0 cm. per sq. cm.) and intermediate in the dwarf (80.2 cm. per sq. cm.). This sequence is not what would be anticipated, but it should be added that measurement of vein-length for *Cercis,* however carefully made, may be of little relative value since this species has local areas of the blade, somewhat irregularly distributed, that have the minor veins much closer together, with corresponding increase in total vein length per unit area. A given sample, therefore, may be far from representative of the blade as a whole, and readings for certain stations of a given blade may appear to be inconsistent with others of the same leaf.

Cell size for these three leaves was measured in the upper epidermis of two stations, one central and the other marginal, and the mean was used for the given leaf. Average cell sizes were, sun leaf 665 sq. μ, shade 526sq. μ and dwarf, 499 sq. μ. The sun leaf had larger cells nearer the center of the blade while the others had larger cells in the sub-marginal stations. Obaton reported no study of vein length or cell size in his paper.

Cercis leaves differ from any other studied by the writer in having greater cell-width in the spongy mesophyll than in the upper epidermis. This disparity was least in the sun leaf and greatest in the shade leaf where the sponge cells measured in the paradermal plane, may be one fifth greater than those in the upper epidermis of the same sample. Due to the irregular outline of sponge cells, their actual area may be less but the total paradermal spread of cells is greater in this layer than in the epidermis. This was found to be true also in other *Cercis* leaves not involved in this series.

Conclusion and Summary. The diminutive leaf of *Cercis canadensis* seems to be a fairly normal shade leaf. In outline of blade, major venation pattern, cell size, total thickness, epidermal development and amount of mesophyll it fits into the sun-shade series of this species. In but two respects was it out of expected position. The total vein length per unit area for the dwarf ranked above that of the large shade leaf of higher insertion, and in relative amount of spongy mesophyll it also stood next to the sun leaf. But as noted above, measurements of vein length in this species are complicated by marked irregularities in the distribution of the minor venation. The relative amounts of sponge in these three leaves showed a range of less than 5 μ and minor fluctuations in this layer are not significant compared with the very great differences found in their palisade. The findings here recorded for the dwarf, palmate leaf of *Cercis* reveal rather striking contrasts to the results noted by Obaton for dwarf, pinnate leaves. The latter differed from the larger leaves of their respective species in form and major venation, but agreed closely with them in blade thickness and total mesophyll, as well as in sponge and palisade distribution. Such contrasts between dwarf palmate and pinnate leaves suggest that growth patterns are related to the major venation system and that the palmate type, with several digitate primary veins, offers greater freedom of expression in dwarf leaves than is found in the pinnate blade. It is to be recalled of course that while the survey of seven stations per blade protects the values for a given leaf, adequate sampling calls for the study of more leaves per category. This is, accordingly, a preliminary report and the findings are presented in the hope that they may be helpful in the selection of material for leaf study.

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A NOTE ON AXIS RESTORATION IN A GYMNOSPERM TREE

ROBERT B. WYLIE

Injury to the major axis of a tree with excurrent growth often results in the development of a dwarfed or unsymmetrical crown. In the case of certain gymnosperms the lost apical shoot can be restored by bending upward one of the adjacent lateral branches and fastening it in upright position. In this way it may be induced to develop into a radical, lead shoot and dominate the further growth of the tree. While this practice is fairly well known it should occasionally be brought to the attention of the general public. The following paragraphs record another instance of the successful substitution of a lateral branch for the lost apical shoot of an injured pine tree.

The tree, a white pine (*Pinus Strobus*), had been transplanted, when "three or four years of age," from Michigan to a lawn in Iowa City. It stood near the north east corner of a large residence which cut off some of the direct sunlight early afternoon. It was also shadowed earlier and later in the day by taller trees on adjacent lots. The transplanted pine had made a normal growth and was about 16 years of age at the time of the accidental destruction of the apical shoot during the late summer of 1934.

Early that autumn a lateral branch about 2 feet long was bent upward and fastened rather loosely to a stick perhaps four feet long which had been firmly tied to the main stem below at two or three levels. Through a number of months the bands holding the upturned branch to the splint were gradually tightened, thus bringing it more closely to the support, but there remained a considerable arch at its base. After two years' growth and the tree had a fairly hopeful appearance, the splint was removed. The substitute, terminal shoot had developed radial symmetry and was already appreciably larger than its sister branches. A few years later, when this pine was dangerously loaded with ice, all branches except the new apical shoot were bent to the ground but it stood erect carrying its ice load without bending except at the tip.

In March 1942 the base of the upturned branch was 2¾ inches in diameter while the four other members of its original whorl

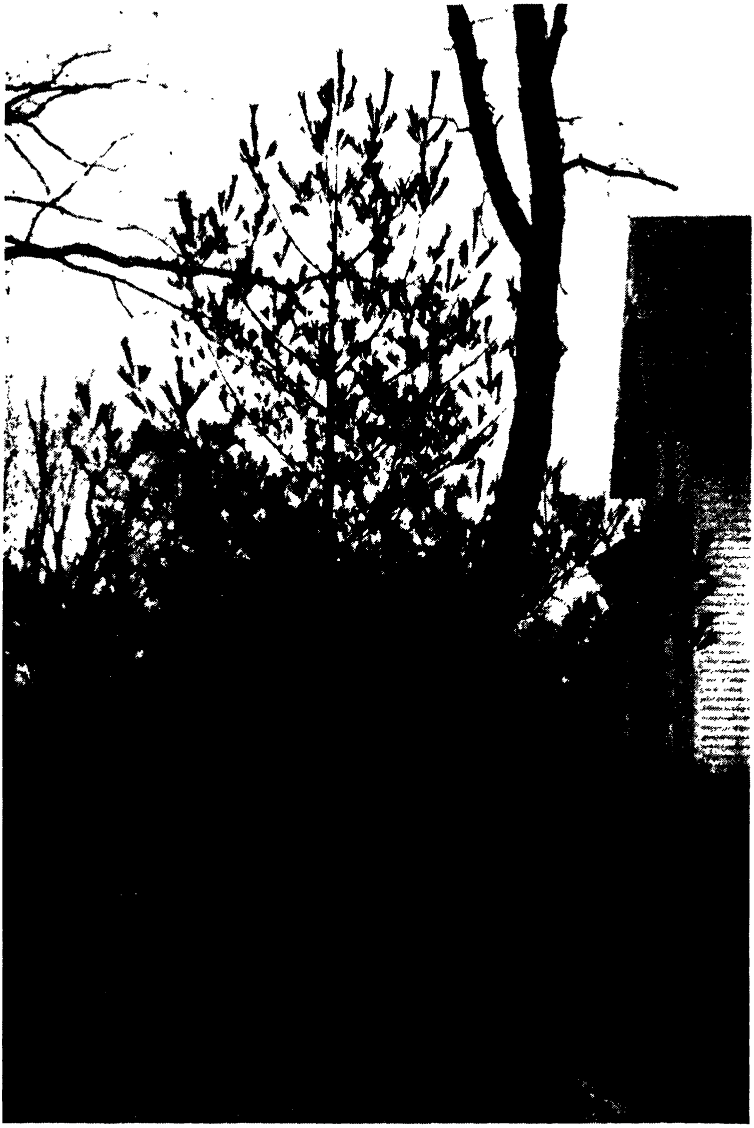

FIG. I

White pine tree, now twenty-four years old. The apical shoot was broken out in 1934; a lateral branch was then raised up and fastened in vertical position. This branch soon developed radial symmetry and dominated the further growth of the tree. A slight angle in the avis indicates the base of the new apical shoot. The picture, taken March 1942, shows the present form of the tree after seven years of renewed growth.

averaged about 1 inch in thickness. The cross sectional area of the new apical shoot was therefore nearly twice the combined cross sectional areas of the sister branches, measured at their common node. Meanwhile the curve near the base of the upturned branch had disappeared and the tree to the casual observer is a normal white pine.

Inspection from certain angles of course reveals the modified habit of this tree. There is a pronounced narrowing of the crown in the region of operation. This is due in part to the dwarfing of the lateral branches of the first and second whorls on the substitute axis, and also in part to the rapid growth of the sister branches during the "interregnum". Since at the present time adjacent branches both above and below the dwarfed whorls are growing rapidly, they will soon round out the top.

The newer portion of the axis is not quite in line with the lower part but the upper is more nearly vertical. It seems likely that this has been due in part to growth adjustments at the base and partly to the fact that the tree is emerging from the shadow of the nearby house. An accompanying figure shows the pine at this date, now approximately 24 years old, and after 7 years of re newed apical growth.

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TOTAL LENGTH OF STEM DEVELOPED FROM A SINGLE SEEDLING OF CUSCUTA

H. L. Dean

Curiosity as to the total length of stem that could be developed from a single seedling of Cuscuta promoted a series of outdoor experiments in an attempt to answer this question.

Seeds of *Cuscuta Polygonorum* Englm. were germinated on wet filter paper in glass moist chambers and vigorous seedlings placed in contact with young willow shoots growing on the banks of the Iowa River near Iowa City, Iowa. The area surrounding each infestation was carefully inspected to make certain that no other Cuscuta seedlings were present. A circle around the site of each infestation was stripped bare of all vegetation in order to confine the dodder growth to a known area and to facilitate observations. Each infestation was examined twice a day until the dodder seedlings were well established and regular inspections made twice a week thereafter. These precautions made certain that no other dodder seedlings, from naturally placed seeds, intruded upon the experiments.

One experimental infestation made April 30, 1938, developed without interference or mishap and the resultant dodder growth (Fig. 1) was collected and measured August 26, 1938. The host plants affected were mainly *Salix* sp., and *Polygonum virginianum* L. The host plants were cut off at the ground level and the entire mass of host and parasite stems taken into the laboratory for measurement of the dodder. Each fragment of Cuscuta stem was carefully measured by hand, using a meter stick attached to a table top. All stem measured was alive and functional, no dead fragments or extremely small gauge pieces were considered. The tightly coiled spirals about the host stems were not removed and no estimation of their length was included in the final total. In all, 316 pieces of dodder stem were measured. The longest piece was six feet nine inches in length and the shortest three and one quarter inches. The total length of stem developed from this single seedling of Cuscuta was 2,406 feet. This length is due to the repeatedly branching habit of the dodder. It is probable that under more ideal growing conditions a single dodder seedling would develop a mile or more of stem. The total stem length in a large dodder patch must be astounding and the problems of conduction decidedly unusual, especially with many haustorial attachments on a variety of host plants.

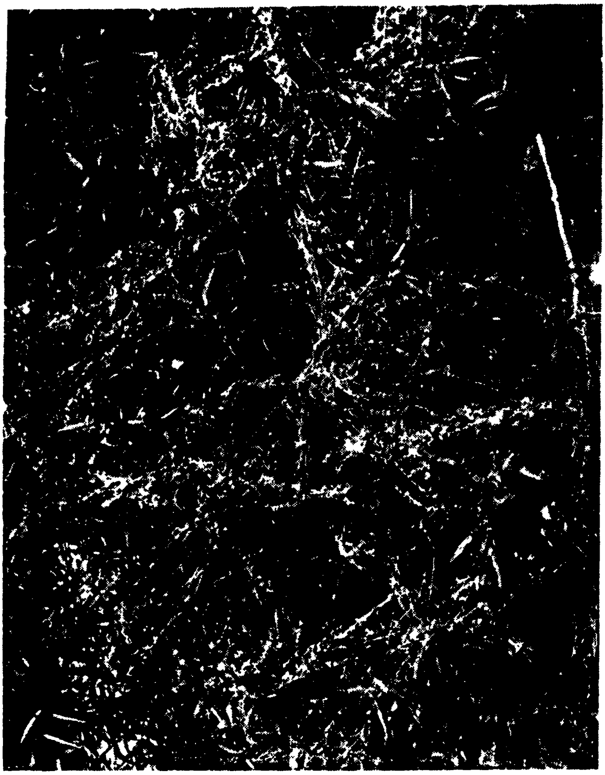

Fig. 1. Dodder growth developed from a single seedling of *Cuscuta Polygonorum.* Englm. The total length of dodder stem was 2,406 feet.

The length of stem developed by this single seedling of Cuscuta is not imposing when compared with the total length of all roots formed on a single plant of winter rye. Dittmer (1937) has demonstrated that the length of such a root system (developed in slightly less than two cubic feet of soil) was 387 *miles.*

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PERMANENT SLIDES OF PLANT CUTICLE STAINED WITH SUDAN IV AND SUDAN BLACK B

H. L. DEAN AND EDWARD SYBIL, JR.

Sudan IV is commonly used to stain fats, oils, suberin, and cutin. Materials stained in this dye are usually mounted temporarily in glycerine and are seldom kept as permanent slides. This may be due to the fact that balsam, clarite or similar mounting media, cannot be used to make permanent slides of preparations stained in Sudan IV. The dye is immediately removed by the xylene or toulene solvent of these media, leaving the preparations colorless. Thick fructose syrup and white Karo have been suggested as substitute mounting media and often make good mounts. A better mounting medium for this purpose is the commercial product, Clearcol. (Obtained from H. W. Clark, 5419 32nd St., N.W., Washington, D. C.) Oil soluble dyes such as Sudan IV, Sudan Black B, etc., are not removed from cutin or other substances stained by these dyes when this medium is used. Permanent mounts can be made of almost any material when Clearcol is used, and objects may be mounted directly from alcohol, glycerine or water. Better results are obtained when tissues are mounted from water. Paraffin sections are desirable when permanent slides are to be made of plant cuticle, but thin freehand sections may be used with success. Paraffin sections should be 7-10 microns thick for general utility slides. Sudan IV may be used alone to stain the cuticle, or a counter stain may be applied to differentiate cellulose walls from the cutin. The following abbreviated staining schedule for apple cuticle may be modified to apply to any type of cuticle.

SUDAN IV AND DELAFIELD'S HEMATOXYLIN

1. Remove paraffin from sections and get slides into tap water. Wash well.

2. Stain in Delafield's hematoxylin, 5-20 minutes. Wash in tap water and examine under the microscope. If the stain is too dark or precipitates appear in the tissues, rinse 3-10 seconds in acidulated water. (1 or 2 drops concentrated HCL to 100 c.c. water). Wash *immediately* in tap water containing a few drops of a 0.1% aqueous solution of lithium carbonate. The

alkali restores the blue color of the hematoxylin, made reddish in the acid bath. For further details on the use of Delafield's hematoxylin see Dean (1940, 1941).

3. Wash well in tap water and pass through the alcohol series to 70% alcohol.
4. Stain 5-20 minutes in Sudan IV (.5% solution in 70% alcohol).
5. Rinse quickly in 50% alcohol and get into tap water. Wash well.
6. Mount in Clearcol.

The red color of the Sudan IV retained in the cutin contrasts well with the blue of the Delafield's hematoxylin in the cell walls, and a sharp differentiation is thus obtained between these parts. Slides made in this manner four years ago still retain their colors undimmed and the Clearcol remains water-clear over the sections.

Sudan Black B has recently been recommended (1932, 1935, 1939, 1940) as a precise stain for fat particles, especially in bacteria and leucocytes. Sharper staining is claimed for this dye than can be obtained with Sudan IV. Because this stain appeared to give such a good result with fat particles it was believed that it might also be used to stain suberin and cutin. Accordingly, a

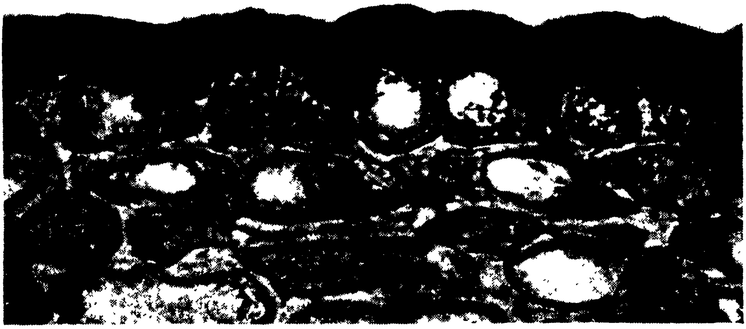

Fig. 1. Cuticle of gano apple stained in Sudan Black B, counter-stained in Alizarin Red S.

series of experiments were made and the present note may be considered a preliminary report on the ability of this dye to stain cutin. Hartman (1940) recommended that this stain be dissolved in either 70% ethyl alcohol or in ethylene glycol. In the present study the following formula was developed and used for all work with this dye. Dissolve .2 gram of Sudan Black B in 100 cc. of 95% ethyl alcohol; to this solution add 50 cc. of glycerine, mix well and filter. This dye stains very rapidly and a stronger solution is not recommended for general use. Solutions of dye made in this manner are still effective seven months after mixing, and show no signs of deterioration. Previously (1935) this stain had been described as losing its efficiency in a short time. The following staining schedule is for paraffin sections of apple cuticle but may be modified for freehand sections. The dye may be used alone or with a counterstain.

Sudan Black B and Alizarin Red S

1. Remove paraffin and get sections into 70% alcohol. Wash well.
2. Stain in Sudan Black B, 10-25 seconds; rarely will it be necessary to stain as long as 40 seconds.
3. Rinse in 70% alcohol and get into tap water. Wash well.
4. Counterstain in 1% aqueous Alizarin Red S, 2-8 minutes. Alizarin Red S stains both cell contents and cell walls but this indiscriminate staining does not appear to affect the sharpness of the Sudan Black B.
5. Wash well in tap water to remove all surplus stain.
6. Mount in Clearcol.

A temporary counterstain may be applied instead of the Alizarin Red S. Stain in a 5% aqueous solution of Phloxine, 20-40 seconds. Wash well in water and mount in glycerine. This stain fades and cannot be used for permanent slides.

Sudan Black B stains cutin very sharply and is easily as precise in this respect as Sudan IV. Stained cutin has good visibility, and the blue-black color is better to photograph than a red-stained preparation of Sudan IV. Preliminary trials indicate that Sudan Black B is also effective as a stain for suberin. Experiments are still in progress with this dye and additional results will be reported later.

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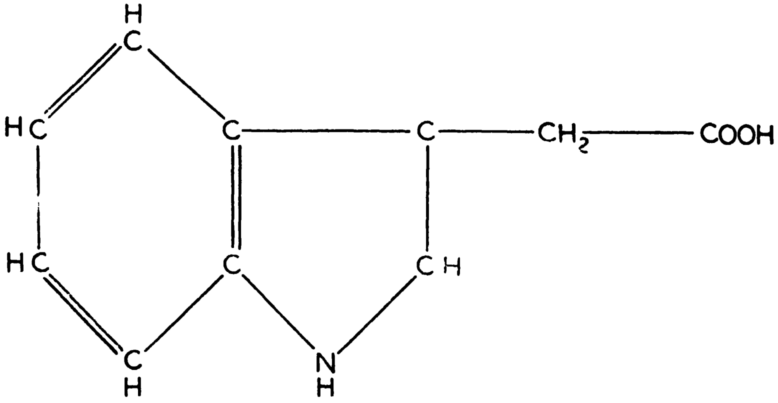
HISTOLOGICAL RESPONSES OF STOCK (*MATTHIOLA INCANA*) SEEDLINGS TREATED WITH B-INDOLYL ACETIC ACID

F. M. Turrell and L. C. Bauguess

Kögl, Haagen Smit and Erxleben (1934) confirmed the finding of Salkowski and Salkowski in 1895 that urine contained B-indolyl acid, and found that this substance accounted for a portion of the activity of urine in promoting the growth of plants not accounted for by auxentriolic acid and auxenolonic acid. Majima and Hoshino (1924) had already developed a method for the synthesis of B-indolyl-acetic acid so that it became evident to the authors that sufficient amounts of B-indolyl acetic could be made readily available for plant growth hormone studies.

The junior author having worked with the synthesis of indole derivatives for the past few years (Berg and Bauguess, 1932; Bauguess and Berg 1934a, 1934b) undertook and succeeded in the synthesis of B-indolyl acetic acid. Mixtures of the acid in lanolin paste were active in bringing about the curvature of the Avena coleoptile. It had a melting point of 164-166° C, uncorrected, 8.04% nitrogen and a neutral equivalent of 176.3. The corresponding theoretical values were m.p. 165° C, 7.99% nitrogen, and a neutral equivalent of 175.1.



Stock plants were grown from seed in flats in the greenhouse. When these had reached a height of from 1.3 cm to 1.4 cm (nineteen days after planting) one set of plants was watered with 15 cc of distilled water and the other with a solution of 1 mg of B-indolyl acetic acid to 15 cc of distilled water (1:15,000). Photographs of representative samples of the treated and untreated plants were made ten days later (fig. 1 and 2).

Sections of thes tem were made near the tips of ten plants and portions were also cut from central portions of leaves of ten plants. The sections were killed in formalin-acetic alcohol, Rawlin's formula no. 2, dehydrated in a graduated series of butyl alcohol, embedded in paraffin, sectioned and stained in Delafield's haematoxylin and safranin, and mounted on microscope slides. All tissue measurements have been made using these permanent prepared slides.

1. *Effect on stem tissues.*

Table 1. Sizes of cells and tissues in stems of hetero-auxin treated and untreated stock seedlings. Measurements in microns.

Treatment	Stem diameter		Vascular cylinder diameter		Cortex thickness		Cortex cells	Stem
	long	short	long	short	long	short	length	length
Treated	1691.7	1357.1	799.4	632.1	381.0	248.0	230.5	29,600
Untreated	1803.2	1338.5	799.4	520.5	443.0	318.0	172.0	19,200

The treated plants grew much taller (table 1) and produced much thicker leaves which showed a tendency to roll as shown in figures 1 and 2. Microscopic measurements on the stem diameter showed that the long (major) diameter of the treated plants was much smaller than that of the untreated plants but that the short (minor) diameter was approximately the same (table 1).

In the vascular cylinder the long (major) diameters were about the same in treated and untreated plants. However, the treated plants had a significantly larger vascular cylinder when the short (minor) diameter was measured (table 1). However, the cortex thickness of the treated plants was smaller than the untreated when the short (minor) diameter was measured, thus compensating for the larger short (minor) diameter in the vascular cylinder of the treated plant stems (table 1). The long diameter measurement of the cortex indicated that this tissue was narrower in the treated plants than in the untreated (table 1).

As shown in table 1, the cortex cells measured from longitudinal sections of the stem were much longer in the treated than in the untreated. This fact accounts for the greater height of the treated plants. Compare figures 7 and 8.

2. *Effect on leaf tissues.*

The seedlings treated with B-indolyl acetic acid developed leaves having the same upper epidermal thickness as the controls (un-

Table 2. Sizes of cells and tissues in leaves of hetero-auxin treated and untreated stock seedlings. Measurements in microns.

Treated Untreated	Tissue Thickness							
	Upper epidermis	Lower epidermis	Palisade	Sponge	Leaf	Stomatal length	Stomatal width	Palisade cell diameter
	29.2	23.9	45.1	125.2	207.0	30.1	28.9	32.2
Treatment	29.4	21.7	38.3	87.5	177.0	32.4	22.9	25.8

treated), table 2. The lower epidermal thickness was slightly greater (10.1%) in the treated than in the controls (table 2). The thickening of the lower epidermis in the absence of thickening in the upper, in part explains the rolling of the leaves of the treated plants. Palisade, sponge, and leaf thickness were all greater in the treated plants than in the controls (table 2). The greater percentage thickening of the sponge over the palisade may also be responsible for leaf curl. Compare figures 5 and 6. The greater leaf thickness of treated plants is due to greater thickness of the palisade and sponge tissues. While the leaf dimensions were not measured it appears from the measurement of the stomatal width (guard cell + stomatal pore) and from measurement of the palisade cell diameters that the leaf of the treated plants expanded more than the leaves of the untreated plants for the palisade cells of the treated plants were larger in diameter, and the short diameters of the stomata were greater than in the untreated plants (table 2.) The comparison of the palisade cell diameters may be made from the photomicrographs in figures 3 and 4.

DISCUSSION AND CONCLUSIONS

B-indolyl acetic acid (heteroauxin) stimulates the growth of young stock seedlings. The effect of this substance seems to be on the cells of the cortex of the stem where cell length is increased bringing about a taller plant.

The hormone also effected a thickening of the palisade, sponge and lower epidermis of the leaf, though the upper epidermis was unaffected. The sponge of the treated plants increased 43.1% in thickness while the palisade increased but 17.7% in thickness. The greater thickening of the sponge probably is the chief cause of the upward rolling of the leaves of the treated plants. While the thickening of the lower epidermis no doubt contributes some force, it is relatively small, however, as compared with that exerted by the thickening sponge tissue.

Growth hormones such as hetero-auxin are known to diffuse and concentrate in plant organs on the side away from the light and to cause growth in this localized region. As the leaves of the stock seedlings were exposed to the most intense light on their upper surfaces the hetero-auxin would be expected to concentrate in the lower tissues of the leaves. This condition may account for the observation that no thickening occurred in the upper epidermis while the palisade and sponge showed progressively higher percentages of thickening, and the lower epidermis some thickening. It suggests that the mechanism of mesophyll and epidermal thickening which results in xeromorphic leaf structure when leaves are exposed to intense light may be due to a hormone in low concentration which tends to diffuse away from the most intensely lighted side of the leaf to the less intensely lighted side, thus accelerating the vertical growth of these tissues.

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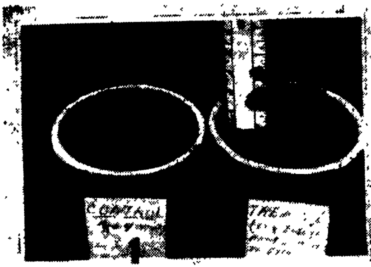
EXPLANATION OF FIGURES

Fig. 1 and 2. Photographs of representative B-indolyl acetic acid untreated and treated stock seedlings.

Fig. 3. Photomicrograph of a tangential section of a leaf of a B-indolyl acetic acid treated stock seedling. Section through the palisade layer. X346.

Fig. 4. Photomicrograph of a tangential section of the leaf of an untreated stock seedling. Section through the palisade layer. X346.

Fig. 5. Photomicrograph of a transverse section of a leaf of a B-indolyl acetic acid treated stock seedling. X164.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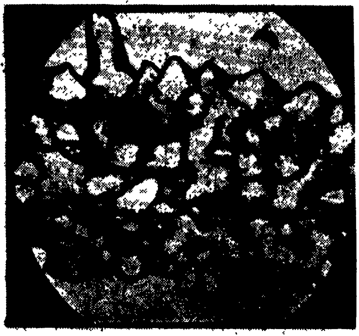

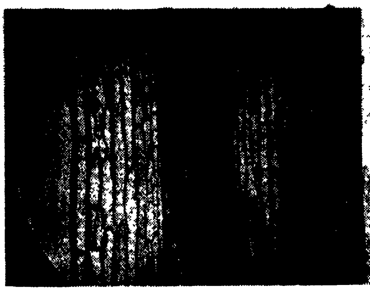

Fig. 6. Photomicrograph of a transverse section of a leaf of an untreated stock seedling. X164.

Fig. 7. Photomicrograph of a longitudinal section of the stem of B-indolyl acetic acid treated stock seedling. X88.

Fig. 8. Photomicrograph of a longitudinal section of the stem of an untreated stock seedling. X38.

A QUALITATIVE STUDY OF THE EFFECT OF SOFT X-RAYS ON THE ACTIVITY OF B-INDOLYL ACETIC ACID AS A GROWTH SUBSTANCE

F. M. Turrell and Harold Kersten

Long and Kersten (1936) found small doses of soft X-rays (long wave length) stimulate the growth of plants from seeds. Moore and Haskins (1933) observed retardation of growth of plants grown from seed irradiated with X-rays from the Coolidge tube which emanates a large proportion of hard X-rays (short wave length). Skoog (1935) has shown that 92 per cent (1000 units per cc.) hetero-auxin (B-indolyl acetic acid) in water is inactivated by hard X-rays filtered through lead, steel, and aluminum filters after exposure of 100 minutes, when the X-ray tube was operated at 3-4 milliamperes at 900 kilovolts. This raises the question as to whether "hetero auxin" which is inactivated by hard X-rays is also inactivated by soft X-rays.

The authors express their appreciation to Dr. L. C. Bauguess for the hetero-auxin which he kindly supplied for the purposes of this study.

METHODS AND MATERIALS

The authors have studied the effect of soft X-rays from a gas tube using a copper target as described by Kersten (1934) on hetero-auxin (B-indole acetic acid). The tube was operated at 38 kilovolts and 20 microamperes at a distance of 3.3 cm from the focal point of the X-ray tube. The K_a (1.54 Å) line was approximately 3.5 times as intense as any other portion of the spectrum except the K_b line (1.38 Å) of copper which was approximately 1.3 times the intensity of any other rays except K_a. The minimum wave length emitted was not less than 0.35 Å.

Hetero-auxin was weighed out into ground glass deep-well slides. A cover glass was sealed over the material with a small amount of paraffin, and the dry material irradiated. A weighed quantity of lanolin was mixed with the irradiated hetero-auxin. Coleoptiles of *Avena sativa* grown on moist filter paper in large covered dishes were treated with the mixture. The authors wish to express their appreciation to Mr. L. C. Burnett, Iowa State College for supplying seed of the pure strain of *Avena sativa* (Iowa No. 2017, rustless) for this study. All tests were carried out in a constant temperature room at 78° F. under red light. At the time the tests were made, the atmosphere in the covered dishes was approximately 100 per cent relative humidity. Ten coleoptiles were used to test the activity of the X-irradiated hetero-auxin in lanolin and ten were used to test non-irradiated hetero-auxin in lanolin. Concentration of the hetero-auxin (irradiated and non-irradiated) was equal for a given trial. A small quantity of the lanolin paste mixture was placed on the coleoptile with a finely drawn glass rod.

RESULTS

Reference to table 1 shows that heteroauxin in the dry condition irradiated with soft X-rays was not inactivated by exposures ranging from 60 to 360 minutes. Figures 1 to 13 show coleoptiles treated with X-irradiated heteroauxin (dry) in lanolin in various concentrations and for various periods of X-ray treatment. The bending or curling of the coleoptiles indicates that the heteroauxin was still active as a growth substance after irradiation.

Qualitative effect of soft X-rays on heteroauxin irradiated while dry.

Experiment number	Length of irradiation period in minutes	Concentration of heteroauxin in lanolin paste g. per g.		Curvature four hours after treatment	
		Irradiated	Control	Irradiated	Control
5	0	—	0.0004	—	+
5	0	—	0.0000	—	—
1	0	—	0.0000	–	
1	15	?	?	+	+
4	30	0.0002	0.0001	+	+
2	60	0.0366	0.0931	+	+
3	60	0.0054	0.0085	+	+
1	120	?	?	+	+
2	180	0.1937	0.0931	+	+
3	180	0.0251	0.0085	+	+
2	300	0.0808	0.0931	+	+
3	300	0.0028	0.0085	+	+
4	360	0.0001	0.0009	+	+

Distilled water was added to a weighed portion of heteroauxin in deep well slides, and the heteroauxin allowed to go completely into solution. These were then covered with cover slips which were attached with paraffin. As irradiation progressed, the water evaporated until the material became dry. It was then mixed with lanolin and applied to the Avena coleoptiles.

In table 2 results of irradiation of heteroauxin in rather concentrated water solution show that the growth substance thus prepared was not inactivated by exposures of 30 and 138 minutes (fig. 14 and 15).

Qualitative effect of soft X-rays on heteroauxin irradiated in distilled water solution.

Length of irradiation period in minutes	Negative curvature four hours after treatment Control	Irradiated
30	+	+
138	+	+

DISCUSSION

Skoog found that hard X-rays caused the oxidation of auxin and heteroauxin both in the green plant and in vitro. Although irradiation of dry hetero-auxin was not undertaken in his experiments, he protected these growth substances from oxidation when in water solution with nitrogen and chloroform and showed that X-irradiation under these conditions was much slower than in air, or in the absence of air. A 40-minute exposure almost completely inactivated the growth substance under the latter conditions.

Using soft X-rays the writers found in a qualitative way that the activity of hetero-auxin was not greatly diminished as indicated by the curvature of *Avena* coleoptiles when hetero-auxin was irradiated in the dry condition or in small quantities of distilled water.

CONCLUSIONS

Dry hetero-auxin when irradiated with soft X-rays for 300 minutes is not inactivated.

Hetero-auxin dissolved in water in high concentration is not inactivated by long exposures to soft X-rays.

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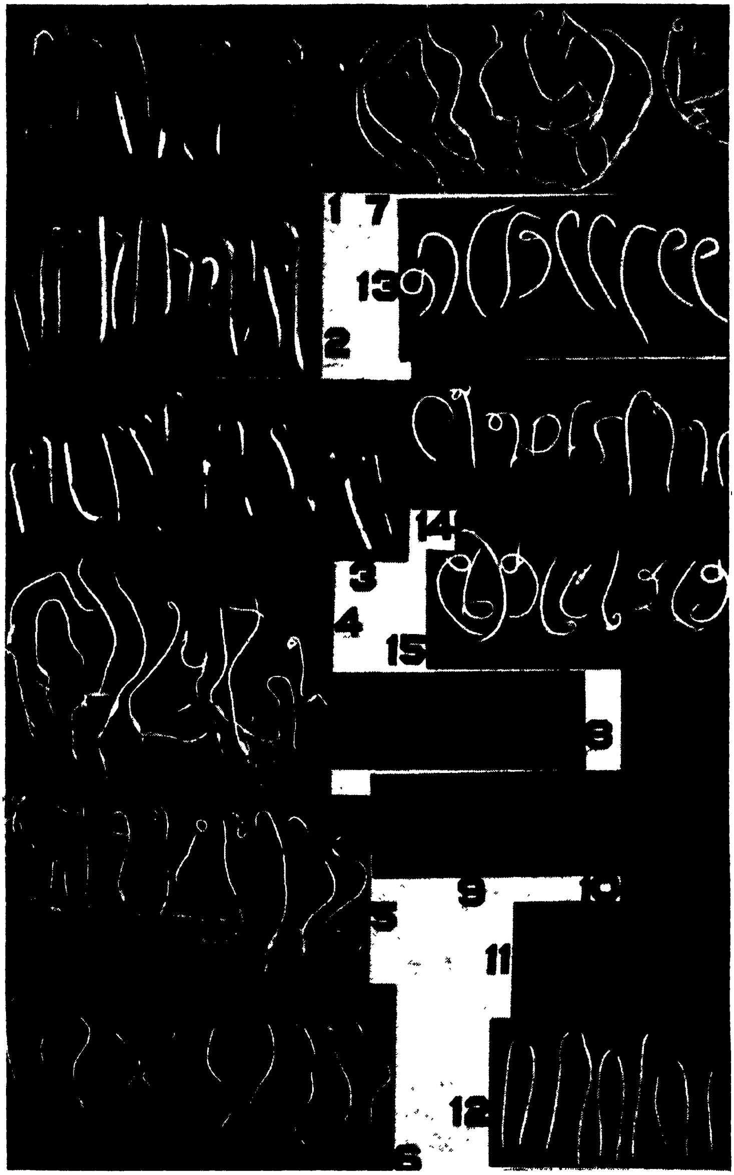

EXPLANATION OF FIGURES

Avena coleoptiles treated with soft X-ray irradiated and non-irradiated B-indolyl acetic acid mixed with lanolin. Photographed 2 to 4 hours after treatment. Photographs for any one experiment are comparable.

Fig. 1 Irradiated dry for 2 hours, experiment 1.
Fig. 2 Irradiated dry for 15 minutes, experiment 1.

Fig. 3	Not irradiated, experiment 1.
Fig. 4	Irradiated dry for 1 hour, experiment 3.
Fig. 5	Irradiated dry for 3 hours, experiment 3.
Fig. 6	Irradiated dry for 5 hours, experiment 3.
Fig. 7	Not irradiated, experiment 3.
Fig. 8	Irradiated dry for 30 minutes, experiment 4.
Fig. 9	Irradiated dry for 6 hours, experiment 4.
Fig. 10	Not irradiated, experiment 4.
Fig. 11	Not irradiated, experiment 4.
Fig. 12	Lanolin only applied (no B-indolyl acetic acid added), experiment 5.
Fig. 13	Not irradiated, experiment 5.
Fig. 14	Irradiated in distilled water 2 hours, 18 minutes, experiment 6.
Fig. 15	Not irradiated, experiment 6.

NOTES ON IOWA FUNGI. IX.

G. W. MARTIN

DELACROIXIA CORONATA (Cost.) Sacc. and Sydow. Figs. 4, 5.

This interesting member of the Entomophthoraceae was first described by Costantin from France as *Boudierella coronata* (Bull. Soc. Myc. France 13: 38. 1897) and shortly afterwards transferred by Saccardo and Sydow (Syll. Fung. 14: 475. 1900) to *Delacroixia*. In the United States it was first isolated in Wisconsin by Gilbert (Trans. Am. Microsc. Soc. 38: 263-269. 1919), who did not, however, ascribe a name to it. A few years later it was isolated from wood in Iowa and published, on what at that time seemed sufficient warrant, as *Conidiobolus villosus* Martin (Bot. Gazette 80: 311-318. 1925). Kevorkian (Jour. Agr. Puerto Rico 21: 191-200. 1937) transferred the species to *Entomophthora*, but Couch (Am. Jour. Bot. 26: 128. 1939) expressed the opinion that it should be retained in *Delacroixia*, in which conclusion I concur.

The fungus has since been isolated in seven other localities. Kevorkian studied three strains, one from Iowa, the *Conidiobolus villosus* strain, one from Cuba and one from Holland. He found that the first two were able to infect termites when these insects were put in culture dishes in which the fungus was growing, but failed to secure infection with the strain from Holland.

Twice since the original Iowa isolation, the fungus has been secured from leaf mold near Iowa City, where it was presumably growing saprobically. In November, 1939, some wood was taken from an old spruce stump at Charles City and put in a moist chamber to develop slime molds. A few days later several small flies emerged, one of which was observed to be infected with a fungus. Examination showed that the parasite was typical *Delacroixia coronata* (Figs. 4, 5) although no trace of the fungus could be discerned on the wood. The fly was submitted to Dr. Eleanor Slifer for determination and she pronounced it to be in all probability one of the gall midges (Cecidomyidae), although the loss of the antennae in manipulation prevented definitive determination.

Delacroixia has been regarded as primarily saprobic, although Kevorkian's experiments have shown that it is at least a facultative parasite. The present instance, while perhaps not to be regarded as a wholly natural infection, is a further suggestion that it may be a true parasite on insects.

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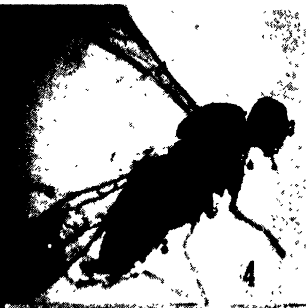
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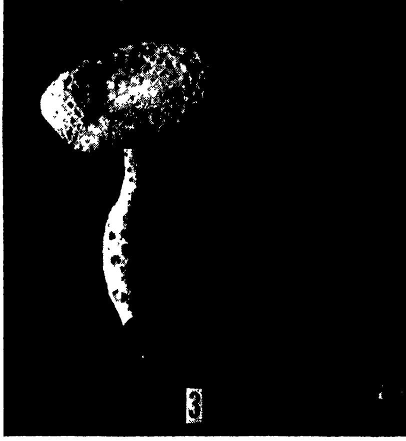
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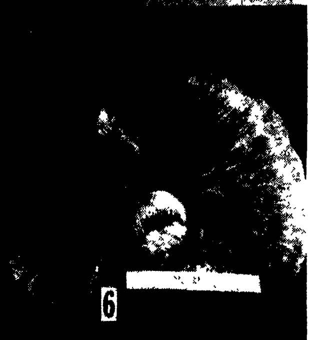
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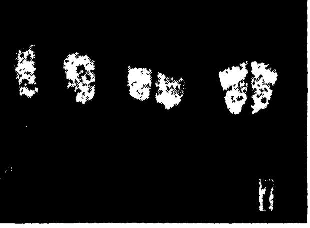
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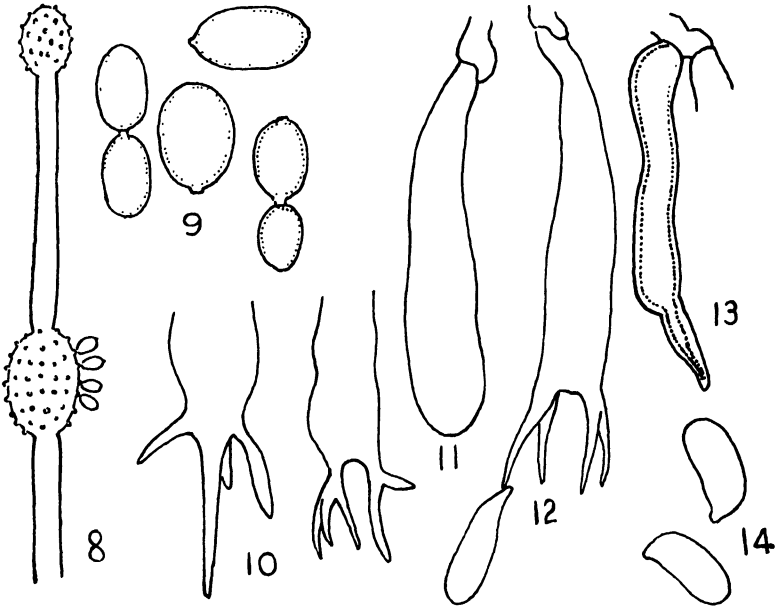
STAMNARIA AMERICANA Massee and Morgan

This small but brilliant orange discomycete is abundant on *Equisetum laevigatum* in the vicinity of Iowa City. The *Gloeosporium* stage appears in late summer on the still erect stalks, while the apothecia appear the following spring on the same stalks, by that time usually prostrate. Seaver (Mycologia 24: 3. 1932) publishes an excellent illustration and points out that the American species differs from the European *S. Equiseti,* with which it has been confused, in the substantially larger asci and spores. The spores of the Iowa collections fall within the dimensions, 24-32 x 7-9 μ, given by Seaver.



HYPOCREA LATIZONATA Peck. Fig. 7.

Originally described from Ohio (in Ellis and Everh. N. A. Pyrenom. 79. 1892) on the basis of specimens sent by Morgan to Peck, this species has since been reported only from Indiana, by Lohman (Proc. Ind. Acad. 47: 91. 1937), who presents an excellent illustration. Both the Ohio and the Indiana collections were parasitizing the cups of *Cyathus striatus* Schw. During the summer and fall of 1941 the species was fairly common at Iowa City, on the same host. The stromata are at first pure white, becoming dingy, then creamy or pinkish—close to vinaceous buff of Ridgway—as the perithecia mature. They are very striking when seen as a pale girdle encircling the dark cups of the host. Although *Crucibulum levis* Pers. was abundant in the immediate vicinity, no evidence was found that the *Hypocrea* ever attacks it.

Lohman expresses some doubt as to the identity of the host in the case of the Indiana collection, based partly on the rather faint striations within the cups of the parasitized basidiocarps and partly on the fact that the host fructifications occurred on soil rather than on wood. In the case of the Iowa material, there can be no question of the identity of the host, since the parasitized basidiocarps, growing on very rotten wood, were accompanied by unparasitized and entirely typical examples of *Cyathus striatus*. There was some evidence of the suppression of striations in the parasitized cups. Furthermore, it is by no means uncommon to find *C. striatus* on soil, especially if it contains woody debris, hence it seems highly probable that Lohman's determination of the host was correct.

While 1941 is the first year I have noted the *Hypocrea,* in previous years I have not infrequently seen a white, mold-like growth on the cups of the *Cyathus*. I am inclined to believe that this has been the young stroma of the parasite and that the species is not uncommon in eastern Iowa.

PEZIZA AMPLISSIMA Fries

This large and handsome discomycete, better known as *Sarcosphaera coronaria* [Jacq.] Schroet., seems not to have been reported previously from Iowa. Seaver (N. A. Cup-fungi. Operc. 236. 1928) says "reaching a diameter of 6 cm." and adds "seldom collected." Velenovsky (Mon. Discom. Bohem. 353, as *Pustularia*) gives the diameter as 8-22 cm. A typical example, collected by Dr. L. W. Danielson at Pine Hollow, Dubuque County, was 12 cm. in diameter, almost spherical except for the stellately opened top. It was in its usual habitat, in humus under pines, and the subterranean development was indicated by the cleared hollow in which it was seated.

Since this species differs from other species of *Peziza* only in its more marked hypogeic habit and stellate dihiscence, which together seem insufficient to justify generic segregation, I prefer to apply Fries's name to it. In any event, the specific name applied by Jacquin seems to have no standing under the accepted rules of nomenclature.

LACHNOCLADIUM MICHENERI Berk. and Curt. Figs. 1, 10-14.

The species of *Lachnocladium* are chiefly fungi of tropical and warm temperate regions, although a few species are widely distributed in cooler areas. No species has heretofore been reported from Iowa. The present species is rather abundant in the vicinity of Iowa City, and may be common in other parts of the State but is likely to be overlooked as a whitish and somewhat wilted *Clavaria*. It may readily be distinguished from a *Clavaria* in the field, however, by its tougher texture, difficult to describe in words but quite unmistakable when known, and by the conspicuous basal mycelium from which the fructifications arise. Burt (Ann. Missouri Bot. Gard. 6:271. 1919) describes the spores as hyaline, and cites specimens from Canada, the Middle Atlantic states, Ohio and Missouri. Coker (Jour. Elisha Mitchell Soc. 42: 253. 1927) comments on the species after examining an Ohio collection, but did not see fresh material. Under the microscope, the spores appear very faintly colored but a spore print is distinctly brownish ochreceous. Burt also notes that when fresh the fungus has a bitter taste. I have tested it several times in the field and should describe the taste, not as bitter, but as slightly and tardily nauseous.

The immature basidiospores (Fig. 12) are curiously long and slender, apparently becoming shorter and thicker as they mature (Fig. 14). The hymenium contains numerous thick-walled cystidium-like structures (Fig. 13) with a slender tip, which, however, does not protrude above the general hymenial level. In addition to these, a collection made in July, 1941, contained many bodies exactly like the basidia except that they were tipped with sterigma-like, but irregular, often enlarged and sometimes branching spikes (Fig. 10). I interpret these as aborted basidia. None were observed to bear spores. Professor Coker has seen some of my material and agrees with the determination.

LACTARIUS PIPERATUS Fries

This common species is also one of the largest in its genus. Kauffman (Agaricaceae Mich. 95. 1918) gives the diameter of the pileus as 4-12 cm. Burlingham (N. A. Flora 9: 176. 1910) says "4-12 cm. or more in diameter." A basidiocarp observed at Iowa City July 7, 1939, was 21 cm. broad, the stem massive in proportion. Other basidiocarps in the vicinity ranged from 18-20 cm. across.

PLEUROTUS ULMARIUS Fries. Fig. 6.

This large agaric is a familiar sight in late fall, growing from knot-holes or the stubs of branches of various frondose trees, particularly elms. It was illustrated by Gilman in his paper on the white-spored mushrooms of Iowa (Proc. Iowa Acad. 48: 100. 1941). Gilman quotes the description of Kauffman (Agaricaceae Mich. 659. 1918) in which the width of the pileus is given as "5-15 cm. or more." Murrill (N.Am. Flora 9: 307. 1916) says: "7.5-15 cm. broad." It is interesting to note that many of the older writers give much larger dimensions. Battarra (Fung. Arim. Hist. 44. 1759) says the pileus may exceed a foot in diameter. Bulliard (Champ. France, Pl. 510. 1790) says "sometimes up to 12-15 inches in diameter." Sowerby (Brit. Fungi, Pl. 67. 1797) makes it "frequently two or three feet in circumference" which would approach a foot in diameter. DeCandolle (Fl. France 2: 138. 1805) gives the diameter as 3-4 decimeters. In view of these figures, the modest dimensions cited by Fries (Syst. Myc. 1: 186. 1821), "3-5 inches and larger broad", seem quite modern. A specimen collected from an elm tree in Iowa City in October. 1941, exceeded all of the measurements cited. The pileus was 41 cm. (16½ inches) in width, tangentially to the point of attachment, 30 cm. across radially and weighed 2012 grams without the base of the stripe, which was too deeply imbedded in the bark to be secured.

PLEUROTUS SUBPALMATUS Fries. Fig. 3.

This striking species seems to be decidedly rare. Lloyd (Myc. Writ. 1: 51. 1901) comments on a specimen from Minnesota, which he illustrates, and notes previous collections from Kansas and Ohio. Kauffman (Agaricaceae Mich. 662. 1918) reports it as rare in Michigan. Both note that it is an anomalous *Pleurotus*. Lloyd suggests that it might be placed either in *Entoloma* or *Claudopus*; Kauffman suggests *Entoloma* and *Heliomyces*.

A specimen collected on a dead elm log in Iowa City by Mr. R. A. Dennison, July 1, 1939, is certainly to be referred to this species, although it does not agree entirely with the published descriptions. The pileus was 37 mm. broad, and since the margin was still inrolled, it had evidently not attained full development. The beautiful salmon-colored pileus (carrot-red of Ridgway, shading to flesh colored on the disk) with its gelatinous surface deeply corrugated in a reticulate pattern is unmistakable. The gills were carrot-red; the stalk, 5 cm. long, was 5 mm. thick and whitish tinged with flesh above; the lower two-thirds was thicker and encased in a yellowish, fleshy sheath sharply separated from the stipe proper although adherent to it, and marked on the surface with brown, slightly sunken areas.

A second, and younger collection consisting of two sporophores, was found by Mr. E. A. Kurth at Wild Cat Den late in the same month. In this collection the sheath was less evident.

PISOLITHUS TINCTORIUS (Pers.) Coker and Couch, Fig. 2.

The occurrence of this interesting gasteromycete in Iowa was noted in the previous paper in this series (Proc. Iowa Acad. for 1939. 46: 94. 1940). Subsequently, I have received from Dr. H. S. Conard a splendid collection, equalling in size any specimens I have seen from the east, where the species is locally abundant in pine barrens. They were growing in disintegrated sandstone in an old quarry at Red Rock, Marion County.

GONATORHODIELLA PARASITICA Thaxter. Figs. 8, 9.

This curious and interesting hyphomycete was described by Thaxter (Bot. Gazette 16: 202. 1891) from Connecticut, as parasitizing *Hypocrea* and *Hypomyces*. Ayres (Mycologia 33: 178-184. 1941) refers to but one collection besides Thaxter's. Since the species is bright reddish brown (about tawny of Ridgway) and grows in dense mats, it is not inconspicuous, and would probably be collected more frequently were it not uncommon. We have a collection from Estherville, growing on *Tomentella* and *Polystictus*, which appears to be entirely typical. The spores are borne singly or in short chains, rather variable in size, up to 10 μ long and 6.5 μ wide, but mostly smaller. The species appeared a second time on moldy wood collected in Iowa City and placed in a moist chamber, and was secured in culture, but has not been kept.

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EXPLANATION OF FIGURES

All reproduced at magnifications indicated. Figs. 8-14 drawn with aid of camera lucida.

1. *Lachnocladium Micheneri*, × 2/3.
2. *Pisolithus tinctorius* × ¼
3. *Pleurotus subpalmatus*, × 2/3
4-5. *Delacroixia coronata* on small fly. 4, to show mycelium, × 44: 5, head enlarged, × 103.

6. *Pleurotus ulmarius*, × 1/9.
7. *Hypocrea latizonata* on *Cyathus striatus*, × 2/3.
8-9. *Gonatorhodiella parasitica*. 8, tip of conidiophore, × 310; 9, conidia, × 1500.
10-14. *Lachnocladium Micheneri*. 10, tips of aborted basidia; 11, young basidium; 12, basidium with immature and elongate spore at- × 1500.

ILLUSTRATIONS OF THE FLESHY FUNGI OF IOWA

III. The Black-spored Agarics

JOSEPH C. GILMAN

This paper is the third of a series intended to present the common fleshy fungi of the state. The purple-brown- and white-spored groups of the gilled mushrooms were previously presented in 1940 and 1941, respectively. The mushrooms that are characterized by black spores comprise the forms described and illustrated in this paper.

Using the same criteria as in the previous papers, i.e., frequency

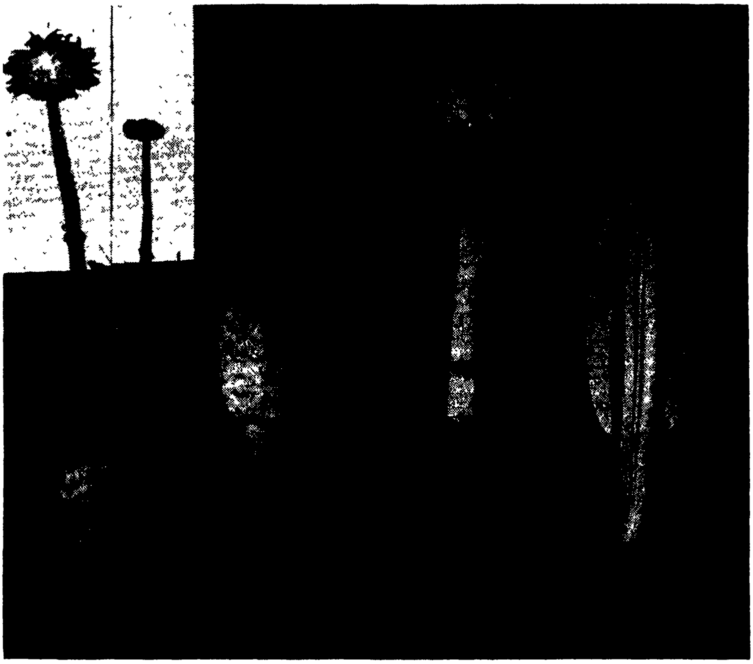

Figure 1. *Coprinus comatus* Fr. Shaggy mane

Cap 7-10 cm. high, cylindrical, then more or less expanded, at first even, the cuticle becoming torn into broad adpressed scales, pale ochraceous, becoming darker in age, interstices whitish. Gills up to 12 mm. broad, almost free, white, crowded, then pinkish, at length black. Stem 10-15 cm. long, 12-17 mm. thick, sub-equal, slightly attenuated upwards, white, even, hollow, more or less bulbous, bulb solid, ring movable. Spores almost black, elliptical, 13-18 x 7-8 microns.

Gregarious. In lawns and fields, very common in autumn, occasionally in spring. Edible.

of occurrence and ease of identification, only two genera, Coprinus and Panæolus, are included: the former with four and the latter with one species.

The genus Coprinus is characterized by the fact that its gills deliquesce loosing the spores into a liquid that they cause to be inky black. Hence the name "inky-caps." Beside the four species described here, which are the large and conspicuous forms, many others, most of them smaller and very delicate, are known. Although all four species illustrated usually are considered edible, a few cases of an allergic type of poisoning have been noted in the literature for both *C. comatus* and *C. atramentarius.* With this fact in mind it would be well to test the individual's reaction to these forms by partaking sparingly before indulging in them.

The descriptions given follow those of Kauffman, Agaricaceae of Michigan.

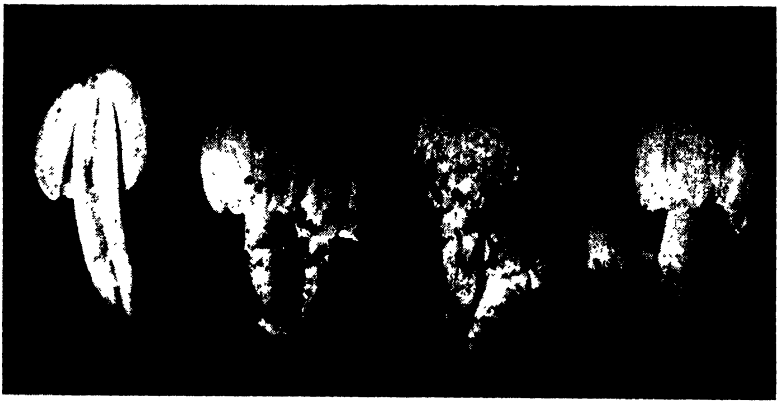

Figure 2. *Coprinus atramentarius* Fr. Gray cap

Cap 5-8 cm. broad when expanded, ovate then expanded, firm, often lobed and plicate, grayish, silky fibrous, or minutely mealy, apex brownish, often minutely squamulose. Flesh thin. Gills crowded, broad, ventricose, free,, white then black, often with a purplish tinge. Stem 10-15 cm. high by 1-2 cm. thick, white, silky shining, hollow, ring basal, very evanescent. Spores 11-12 x 5.5-6 microns. Cystidia numerous, large, subcylindrical.

Common, gregarious or densely caespitose, about stumps or on rich soil but not on dung. Edible.

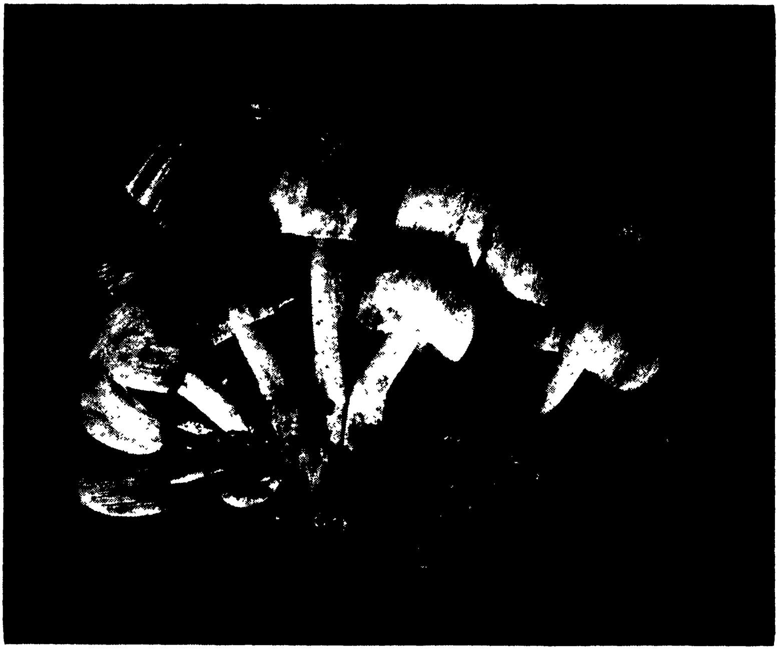

Figure 3. *Coprinus micaceus* Fr. Inky cap

Cap 4-6 cm. across, submembranaceous, elliptical then campanulate, coarsely striate, disk even, margin usually more or less repand, ochraceous-tan, disk darker when young densely covered with minute glistening particles which usually soon disappear. Gills sub-crowded, lanceolate, adnexed, whitish, then brown, finally nearly black. Stem 5-7 cm. long. 4-6 mm. thick, equal, even, hollow, silky white. Spores 7-8 x 4-5 microns, dark brown in mass.

Very common, generally densely caespitose about stumps or trees, or growing from decaying wood buried in the earth. Edible.

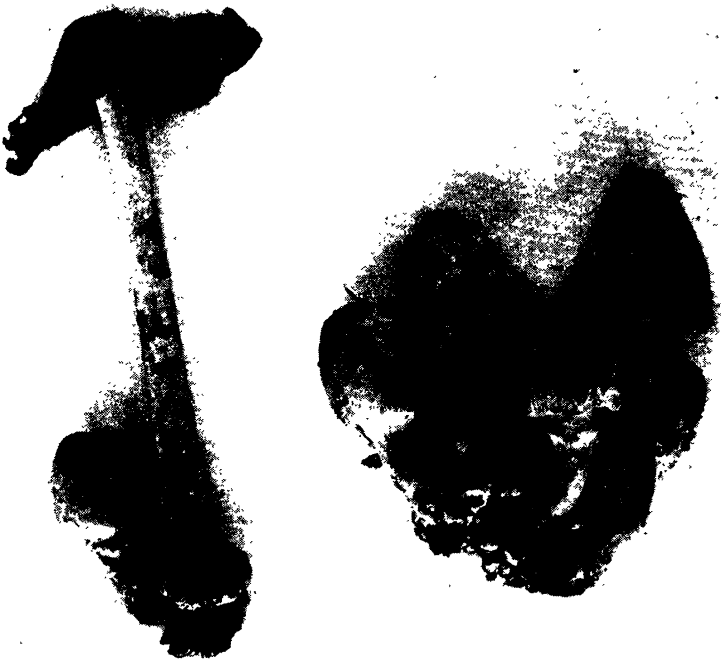

Figure 4. *Coprinus ebulbosus* Pk.

Cap 5-7 cm. broad, thin, bell-shaped, somewhat striate, grayish brown, margin at length revolute, torn, cuticle breaking into broad superficial persistent whitish scales. Gills narrow, thin, crowded, free, slate-colored becoming black. Stem 7-15 cm. long, 10-15 mm. thick, equal, with abruptly swollen base, hollow, white. Spores 7.5-10x5 microns, elliptical.

Caespitose near or upon decaying trees or stumps. Not uncommon.

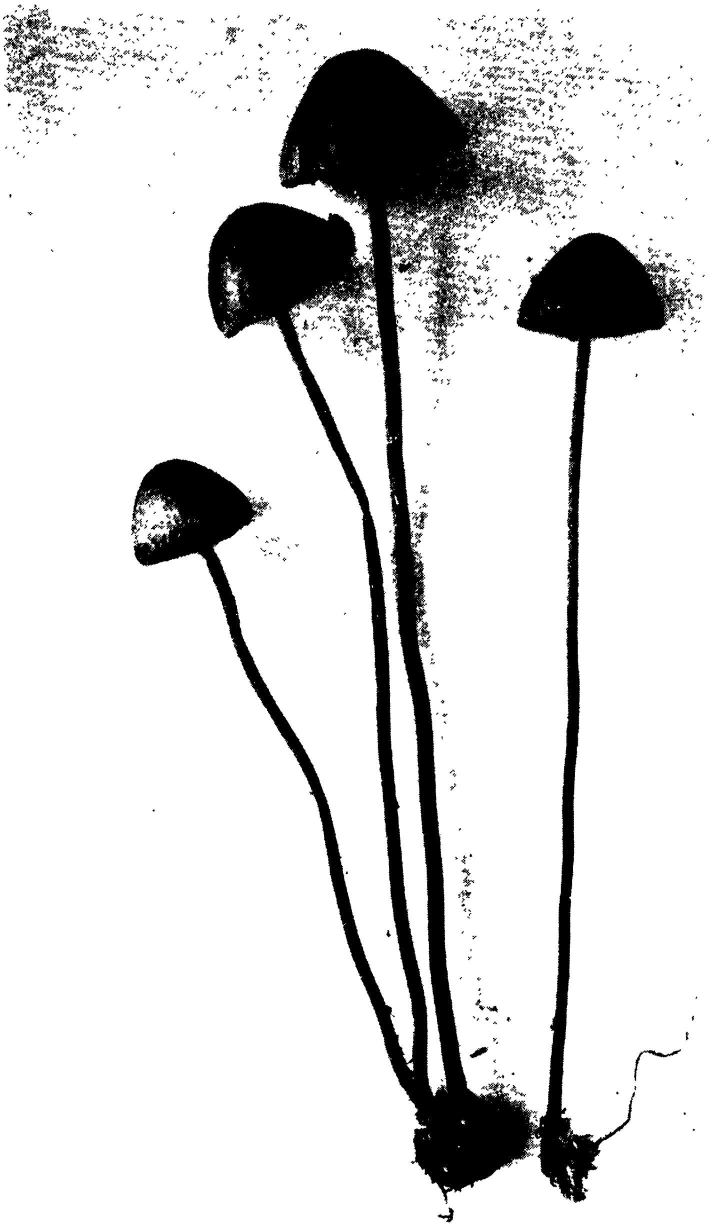

Figure 5. *Panaeolus retirugis* Fr.

Cap 1-3 cm. broad, rather firm at first elliptic-oval, then campanulate-hemispherical, obtuse, glabrous, ***dark smoky when young and wet,*** becoming paler, or in dry weather grayish, pale clay color, or creamy-white, ***shining micaceous*** when dry, surface usually ***reticulate-veined*** on disk, sometimes even, margin connected with stem in young stage by a *floccose-submembranous, ring-like veil,* veil soon broken and margin markedly appendiculate in expanded pileus. Flesh rather thin, equal. Gills adnate-seceding *broad,* ventricose, close, white then variegate-spotted by the black spores, edge white flocculose. Stem 5-16 cm. long, 2-6 mm. thick, equal, cylindrical, sometimes flexuous, whitish, *rufescent* or tinged purplish within and without, darker below, hollow, *often covered with frost-like bloom,* sometimes minutely rimulose, bulbilate. Spores broadly oval-elliptical, ventricose, 15-18 x 9-11 microns, smooth black. *Sterile cells* on edge of gills, narrow subcapitate.

Gregarious or scattered on dung-hills, manured lawns, fields, etc. Very common. Suspected.

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ILLUSTRATIONS OF THE FLESHY FUNGI OF IOWA

IV. Common Fleshy Ascomycetes

JOSEPH C. GILMAN

Superficially the fleshy Ascomycetes may be divided into the cup fungi and the sponge-mushrooms, or morels. The latter are undoubtedly the best known edible fungi in the state, for more people recognize them as mushrooms than they do the agarics. Because they are so well-known, the common forms and the more closely related similar species were chosen for illustration.

Although these species here presented are already very well discussed in the literature, especially by Seaver[1], the purpose of this series of contributions to our Iowa flora would be incomplete

Figure 1. *Peziza vesiculosa* Bull.

Fruiting bodies, in groups or more often arising from a common base, at first closed and globose, gradually expanding and becoming deep cup-shaped, regular in form or irregularly contorted, sessile or with a very short, stout stem-like base, externally whitish or yellowish, with minute wart-like pustules, reaching a diameter of 7-8 cm.; interior of cup pale brown, paler than the outside; asci cylindric or subcylindric; spores obliquely in a single row, ellipsoid, smooth, colorless, 10-11 x 20-23 microns; paraphyses enlarged above, granular within, sub hyaline.

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[1] Seaver, F. J. The North American Cup-fungi (Operculates) New York. 284 page 1938.

should they be omitted. For further information and species not treated here, the above book will be found very satisfactory. The descriptions included are adapted from it.

On manure piles and heavily fertilized soils. A dark brown woods species, *Peziza badia*, is also frequent in Iowa.

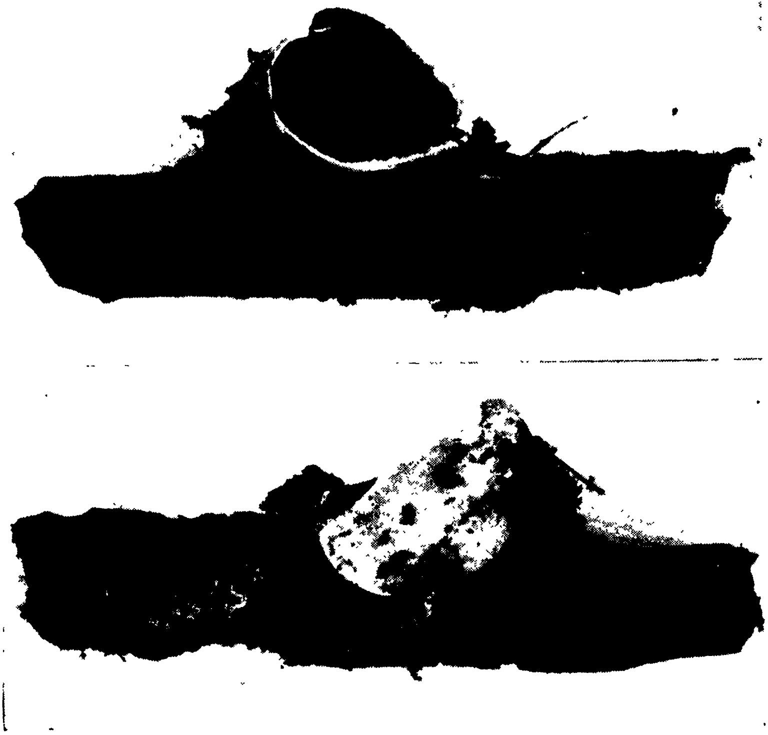

Figure 2. *Plectania coccinea* (Scop.) Funckel Scarlet cup

Fruiting body a rather deep cup-shaped or funnel-shaped scarlet cup, on a long or very short stalk; the margin of the cup usually strongly incurved, externally nearly white and more or less flecked with colorless hairs; interior deeply concave, scarlet, fading when dry; stem stout, 4-5 mm. thick and of variable length, often 2-3 cm. long and again almost lacking, the length of the stalk varying according to the depth at which the sticks on which it grew are buried; asci very long, cylindric, gradually tapering into a stem-like base, reaching a length of 400-500 microns and a diameter of 12-14 microns; spores mostly in one row, long ellipsoid, often containing two large oil drops and numerous small ones, 10-12 x 26-40 microns; paraphyses slightly enlarged above, containing numerous red granules.

On buried or partially buried sticks; early spring. The scarlet cup is usually the earliest of the cupfungi to fruit in the spring. This year a collection of it was made in January. Later in the year, two other members of this group are commonly present in the woods. They are the western cup (*Plectania occidentalis*) and the fringed cup (*P. floccosa*). They are both smaller than the scarlet cup but are red and have a similar habitat. They occur throughout the summer.

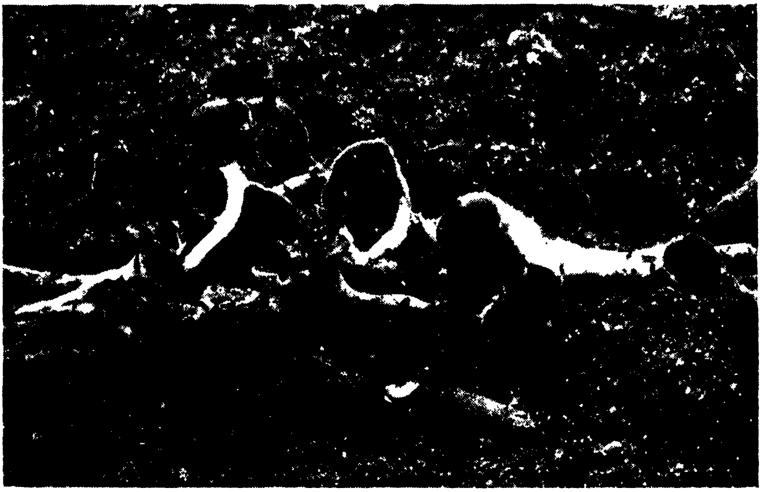

Figure 3. *Plectania occidentalis* (Schw.)

Cups in groups or clusters, shallow cup-shaped to discoid, stipitate, externally whitish, reaching a diameter of 1 cm., hymenium usually concave, bright-red, almost scarlet; stem varying in length according to the depth at which the sticks on which the plants grow are buried in the ground, up to 2 - 3 cm. long and 2 mm. in diameter, asci cylindric or subcylindric, up to 15 - 18 microns in diameter at the tip, tapering below into a long stem-like base; spores in a single row, parallel with the ascus walls or oblique and with ends slightly overlapping, ellipsoid, usually with two oil-drops one in either end which are often surrounded by smaller oil-drops and granules, hyaline or slightly yellowish, 10 - 12 x 20 - 22 microns; paraphyses slender, slightly thickened above, up to 3-4 microns at the tip.

On buried or partially buried sticks in moist soil. Throughout the summer.

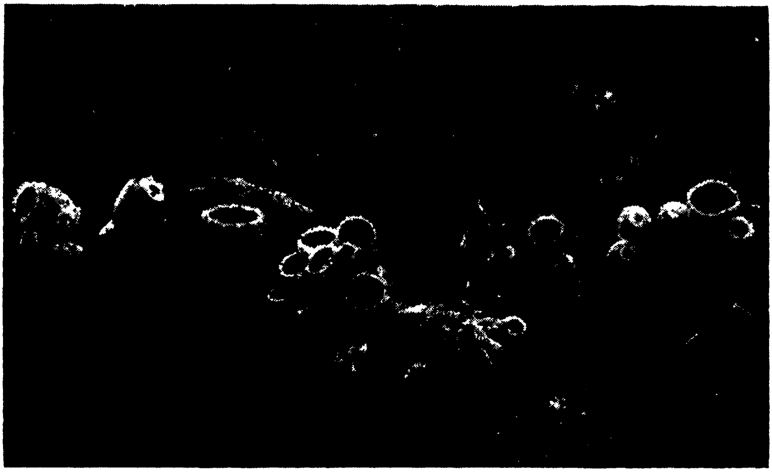

Figure 4. *Plectania floccosa* (Schw.) Seaver

Cups grouped or occasionally clustered, stipitate, infundibuliform with margin strongly incurved in young plants, reaching a diameter of 5 - 8 mm. and a depth of 1 cm., externally clothed with very long, rigid, hyaline hairs which give the cup a very shaggy appearance, rose red; stem slender, gradually expanding into the apothecium above, and variable in length, depending upon the depth of the sticks upon which the plants grow are buried in the ground, hairs about 15 - 18 microns in diameter at the base and gradually tapering into a bristle-like apex, reaching a length of more than 1 mm., septate, thick-walled; asci cylindric, or subcylindric, rather abruptly narrowed into a long stem-like base, up to 300 - 325 microns long, (not including the constricted portion below,) and to 20 microns in diameter at the apex; spores in a single row or with the ends partially overlapping, ellipsoid, with rather strongly narrowed ends, smooth, hyaline or slightly yellowish, 15 - 17 x 20 - 35 microns, paraphyses slender, slightly enlarged above, reaching a diameter of 3 microns at their tips.

On burned sticks in woods. Summer.

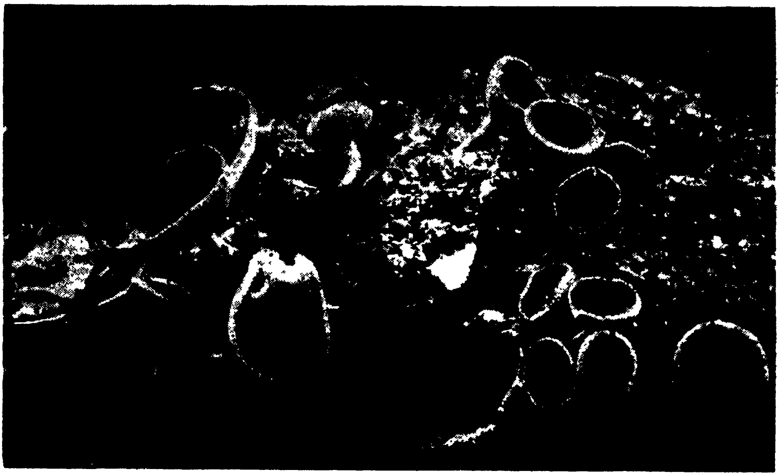

Figure 5. *Paxina subclavipes* (Phill. and Ellis) Seaver

Cups in groups, up to 2 cm. in diameter and 1 cm. in depth, externally cinerious to yellowish or more rarely olivaceous-brown, rough and the roughening consisting of bunches of hairs; hymenium darker than the outside of the cup, brownish; stem slender, even or nearly so, reaching an extreme length of 1 cm. but often much shorter, about 2 mm. thick, covered like the outside of the cup with tufts of hairs, hyaline or faintly yellowish, asci cylindric, up to 250 microns long by 15 microns in diameter; spores in single row, or slightly crowded near the tip of the ascus, ellipsoid, one-celled, containing a single large oil-drop and occasionally a few smaller ones, smooth, hyaline, 9 - 10 x 18 - 23 microns; paraphyses thread-like, about 3 microns in diameter, below, but enlarged above to 7 microns, yellowish-brown.

On ground in woods. June and July.

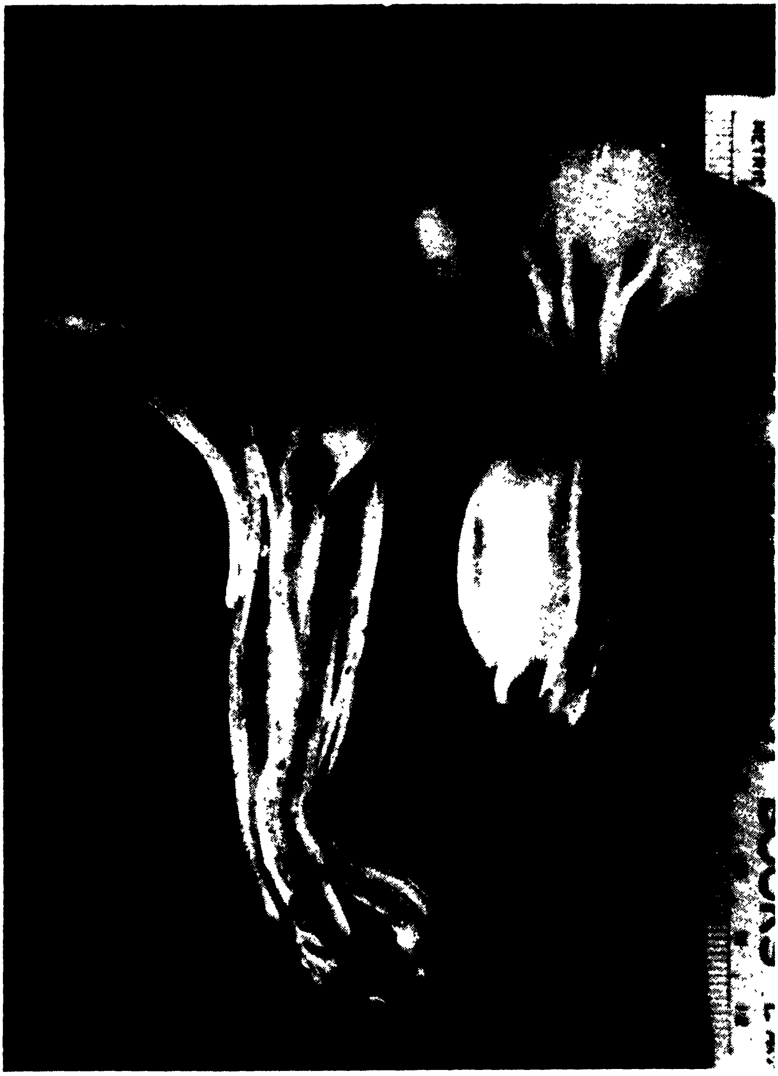

Figure 6. *Paxina acetabulum* (L.) Knutze

Cups, rather deep, reaching a depth of 2-3 cm. or more, rarely expanded and shallow, externally ash-grey to brownish, minutely tomentose and conspicuously veined, stipitate; hymenium darker than exterior, brown to blackish brown; stem short and thick, up to 1-1.5 cm. in length by 1 cm. in diameter, deeply ribbed, the ribs of the stem being continuous with the veins on the cup; the stem gradually expanding into the cup; tomentum consisting of bunches of poorly developed, hyaline hairs, the component cells of which are strongly swollen but contracted at the point of union; asci cylindric above, spores obliquely 1-seriate, ellipsoid, hyaline with a single oil drop, smooth, 12-14 x 18-22 microns, paraphyses straight, enlarged above.

On ground in woods and open places. Early summer.

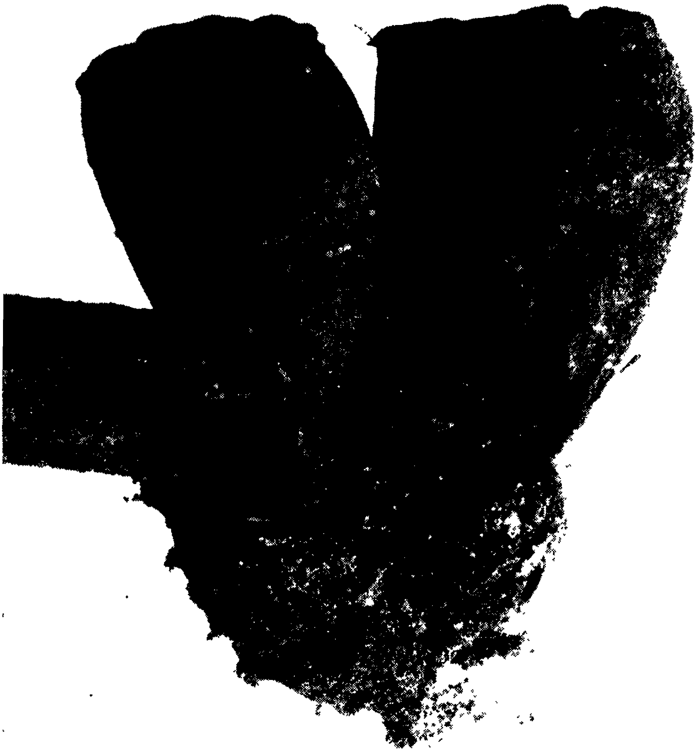

Figure 7. *Urnula craterium* (Schw.) Fr. Black urn

Fruiting body at first closed above, finally opening by a star-shaped mouth which leaves the margin notched and infolded, externally black or brownish-black and clothed with a dense covering of tomentum, reaching a diameter of 3-4 cm. and a depth of 4-6 cm., the substance tough and leathery; interior brownish-black, a little paler than the outside of fruitbody. Stalk reaching a length of 3-4 cm. and a diameter of 5-8 mm., even or very slightly grooved near the base, black or brownish-black and attached to the substratum by a dense mass of black mycelium, gradually expanding above into the fruit body; hairs variable in length, thin walled, sparingly septate, flexuous, about 10 microns in diameter and of nearly uniform thickness throughout their entire length. Asci cylindric above, tapering below into a long stem-like base, reaching a length of 600 microns and a diameter of 15-17 microns; spores in one row, broad ellipsoid, smooth, hyaline, 12-14 x 25-35 microns; paraphyses thread-like, slightly enlarged above, pale brown.

On the ground in deciduous woods, attached to buried or partially buried sticks. Frequent.

Figure 8. *Bulgaria rufa* Schw.

Cups grouped or clustered, sessile or more often short stipitate, attaining a diameter of 2 - 3 cm., at first closed, finally opening and becoming shallow cup-shaped, with the margin incurved, externally blackish-brown and covered over with clusters of hairs, the substance tough, internally with a gelatinous layer several mm. thick, giving the fresh plants a rubbery consistency, on drying becoming leathery and strongly wrinkled; hymenium slightly concave, pale-reddish or reddish-brown, stem reaching a length of 1 cm. and a diameter of 4 - 5 mm., attached below by means of a dense mass of black mycelium which reaches a diameter of 7 - 8 microns; hairs blackish-brown, similar to the mycelium at the base of the stem but shorter; asci cylindric above, gradually tapering below into a long stem-like base, reaching a length of 275 - 300 microns and a diameter of 12 - 14 microns; spores in a single row, ellipsoid, with the ends strongly narrowed, hyaline, granular within, 10 x 20 microns, paraphyses thread-like, scarcely enlarged above.

Common in woods attached to buried sticks. Early summer.

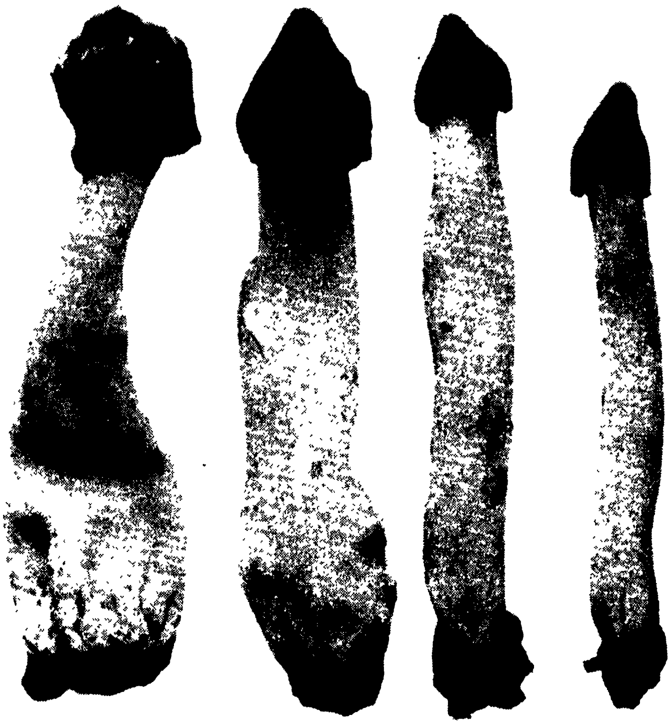

Figure 9. *Morchella hybrida* (Sow.) Pers. Hybrid morel

Head bell-shaped or subconic, reaching a length of 2 cm. and a diameter of 1.5 cm., the margin free about half way up; pits irregularly rounded or elongated, reaching a diameter of 5-10 mm., yellowish within; ribs inclined to be longitudinal or irregularly netted, about 1 mm. thick, lighter than the interior of the pits; stem thick, at first very short, finally reaching a length of 8-10 cm. and a diameter of 2 cm. at the base, gradually tapering upward to about half that diameter, delicately pubescent, whitish or yellowish, often irregularly grooved at the base, nearly even above; asci cylindric or sub-cylindric, reaching a length of 250 microns, and a diameter of 20 microns; spores in one row, ellipsoid, 12-14 x 22-26 microns, hyaline or faintly colored; paraphyses enlarged upwards, hyaline or subhyaline.

On the ground, usually in the margins of woods. May. Edible.

Figure 10. *Morchella esculenta* (L.) Pers. Morel

Head subglobose, ovoid, or elongated, occasionally pointed upward but obtuse at the apex, varying much in size but often reaching a diameter of 4-5 cm., and a length of 7-9 cm.; pits rounded, irregular, occasionally longitudinally elongated, yellowish within, becoming brownish or blackish when dry, reaching a diameter of 5 mm. to 1 cm.; ribs irregularly netted, not longitudinally disposed, the edges rounded about 1 mm. thick and lighter colored than the interior of the pits, usually whitish or yellowish; stem stout but usually not exceeding two-thirds the diameter of the pileus, usually a little enlarged at the base and irregularly grooved, nearly even above, whitish to yellowish, lighter than the head, delicately hairy, reaching a length of 200-250 microns and a diameter of 18-20 microns. Spores in one row, ellipsoid, hyaline, yellowish in mass, 12-14 x 20-24 microns; paraphyses strongly enlarged above, where they reach a diameter of 15 microns, faintly colored.

On the ground in woods and open places. May. Edible. Several other species are to be found in Iowa, the commonest being the following: *Morchella deliciosa*, *Morchella conica* and *Morchella crassipes*.

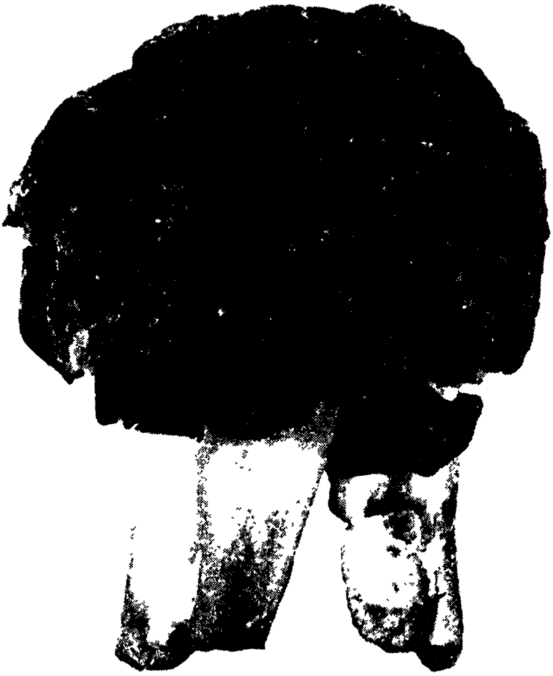

Figure 11. *Helvella caroliniana* (Bosc) Nees

Head irregularly lobed and folded and in places more or less twisted, the ridges often anastomosing and giving to the surface a netted appearance, whitish underneath, the margin adhering to the stem in various places, reaching a diameter of 5-12 cm.; hymenium brown to brownish-black; stem rather short and stout reaching a diameter of 2-5 cm. and a length of 8-10 cm., rather deeply grooved, the color white or whitish; asci clavate or subcylindric; spores in a single row, narrow-ellipsoid and often apiculate, 12-14 x 25-28 microns, usually containing one large oil-drop and often two smaller ones, at first smooth, becoming sculptured; spore-sculpturing assuming the form of minute warts or occasionally reticulations; paraphyses thickened above and colored.

On the ground. May. Suspected.

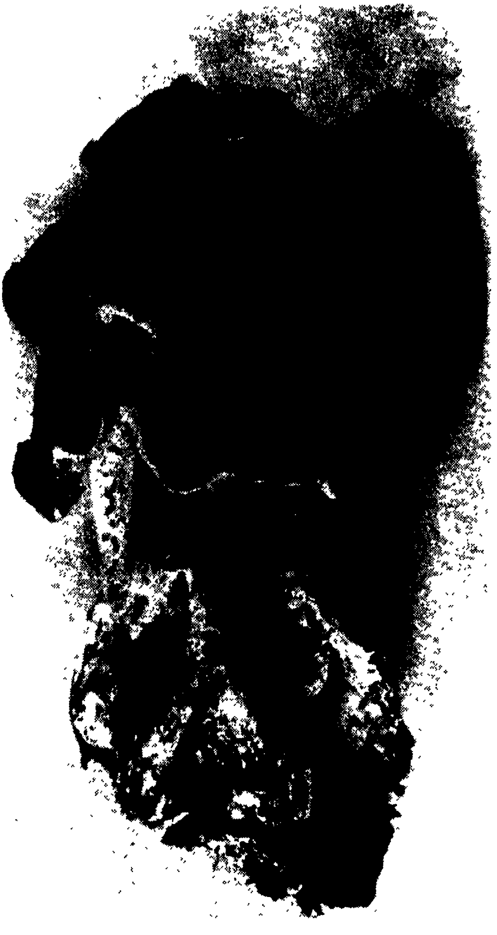

Figure 12. *Helvella underwoodii* Seaver

Cap broad, much contorted, irregularly lobed and folded, in places faintly marked into areas by indistinct anastomosing ridges, 5-12 cm. in its widest diameter; hymenium rich chocolate-brown, whitish below; stem 2-5 cm. thick, 8-13 cm. long, rarely slightly fluted, hollow, white; asci cylindric; spores ellipsoid, 14 x 28-30 microns, usually containing two rather large oil drops, becoming faintly sculptured by small warts or faint reticulations; paraphyses slender, enlarged at the apex.

In rich woods on leaf mould. May. Suspected.

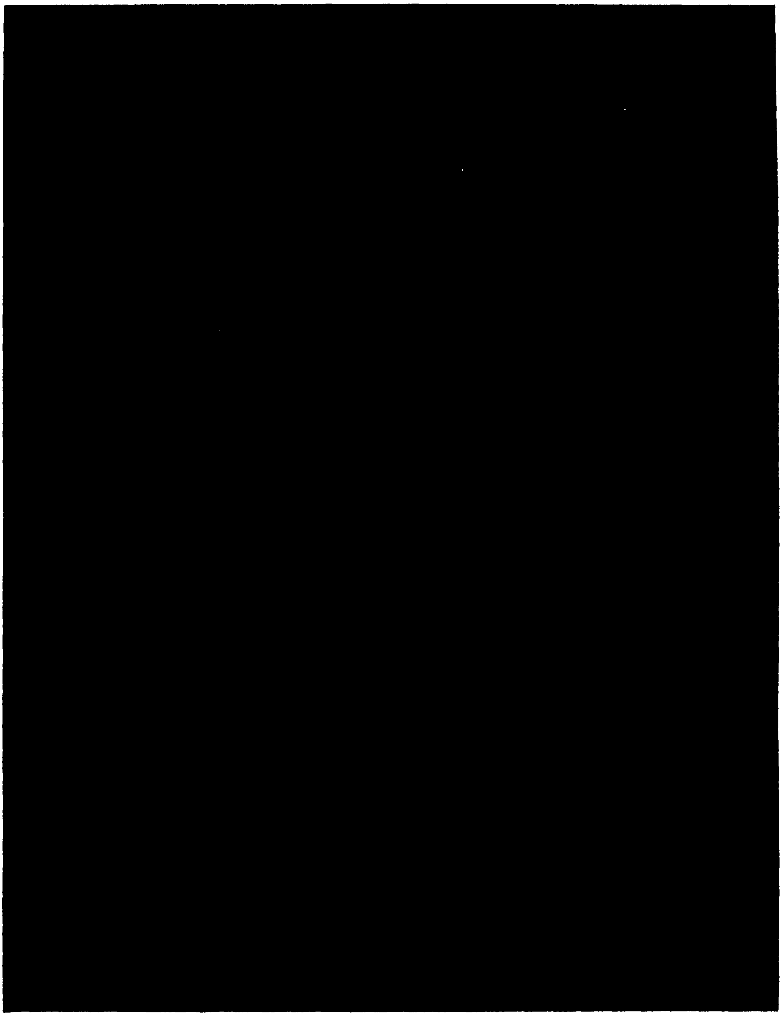

Figure 13. *Helvella crispa* (Scop.) Fr.

Cup mitrate or more often saddle-shaped, reflexed and usually irregularly lobed, reaching a diameter of 4-5 cm.; hymenium white, becoming cream or yellowish with age and especially when dried, even or more or less convoluted; stem up to 6-7 cm. long, and 2-3 cm. in diam., deeply fluted, entirely white when fresh, becoming cream or yellowish with age, still darker when dry; asci cylindric or subcylindric, up to 300 microns in length, 15-18 microns in diam.; spores 1-seriate, ellipsoid, containing one large oil-drop, 12-20 microns; paraphyses enlarged above.

On soil in wooded places. Throughout the summer.

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SOME NOTES ON THE FUNGI OF HENRY COUNTY

MARVIN TULK

For more than a year the writer has been giving special attention to the species of fleshy fungi that could be found on the frequent collecting trips. There is no thought of posing as an expert, but it is hoped that some of these field observations will prove of interest and value.

Our region includes a widely diverse habitat, Skunk River and Big Creek are both within easy reach and furnish deep damp woods, rough hillsides and occasional small water soaked areas. In many parts level farm land predominates.

The writer's collecting was restricted to the vicinity of Mt. Pleasant, Oakland Mills State Park and Richwoods.

Two species of stinkhorn fungi were collected. One, *Simblum rubescens,* was found to be definitely restricted to a small area of cultivated upland soil. This reddish-orange species seemed to be rather abundant during the early part of October. About these scattered plants a good number of carrion flies swarmed, ready to feed and incidentally "to disseminate the spores." Abundant rain fell during this period, making ideal conditions for growth of these plants. The other stinkhorn (*Phallus impudicus*) seemed to be restricted to lawns. This plant in its various stages of development was collected during the entire month of October.

The Inky Coprinus (*Coprinus atramentarius*) was found growing in horse dung. The records for this plant extend from September to freezing weather late in October. This particular species seemed to be well adapted to the needs of the fungus gnats (Mycetophilidæ) for shortly after bringing it into the laboratory, the plant became a wriggling mass of larvæ. Many fleshy fungi, of course, are regularly attacked by fungus gnats. A closely related species, the Glistening Coprinus (*Coprinus micaceus*) was observed growing at numerous spots around the roots of a recently cut cottonwood tree. On October 5th these mushrooms were in their prime, melting into an inky mass within a few hours. The Shaggy-mane (*Coprinus commatus*) was also noted for this area on October 19th, growing among partly decomposed wood.

On the campus of Iowa Wesleyan many brilliantly colored Emetic Russulas (*Russula emetica*) were collected at varied intervals during October.

During the early part of October the common mushroom (*Ag-*

aricus campestris) was abundant in a meadow and a pasture that at one time had been under cultivation. Observation of this particular species was in the Richwoods vicinity.

Throughout the fall puffballs were unusually numerous. They could be found in widely varied localities; the bed of a well-decomposed straw stack supported an unusual number of specimens. Most pastures were well supplied as was also the state park. The most interesting specimen to be collected was the brain-shaped puffball (*Calvatia craniformis*). This unusual-shaped puffball was collected on October 12th. It measured three inches in diameter and was found growing in a pasture. In the discussion of the puffballs, mention should be made of the interesting little earth-stars, as they never fail to attract attention. The Water-measuring Earth-star (*Geaster hygrometricus*) has been reported in various localities. Three were found in the early part of October, later another group was brought in, many of which still were unopened. One was collected from a lawn, the remainder from separate heavy wooded areas.

Many polypores were found, ranging from three-fourths inch to five inches in diameter. There is one polypore which is quite abundant, *Polyporus versicolor,* and one large clump of *Polyporus sulphureus* was found on a Northern Red Oak tree in early October. The first is rather leathery and can be found most any time of the year. On this same tree were widely scattered clusters of the Bear's head Hydnum (*Hydnum caput-ursi*). The collecting of this particular species was confined entirely to the Northern Red Oak.

Two distinct species of coral fungi were collected, the first belonging to the genus *Clavaria,* the other to *Hydnum.* The *Clavaria* is rather stiff and may be collected during the winter in its rigid condition.

Three other groups are represented in the county, each with one species. The first is the Golden Peziza (*Peziza aurantia*) which was found in the state park, both in the early spring and late in October. This bright red cup-fungus was found growing on twigs and in humus on the ground. The second group is represented by the Jew's Ear (*Hirneola auricula-judae*). This strange fungus has been collected several times during the fall and winter, it being found only on horizontal logs. During the winter this fungus retains its moisture making it feel as though it were growing. One specimen of *Helvella lacunosa* was collected during the latter part of October.

MT. PLEASANT, IOWA

THE GENUS THELEPHORA IN IOWA

PAUL L. LENTZ

The genus *Thelephora,* as defined by Fries (Syst. Myc. 1:428. 1821), includes many of the present members of the group and many more which are now placed in other genera. Citing Ehrhart, Crypt. Exsic. No. 178. 1785, as his basis, Fries defined the genus as composed of those fungi having a compact, homogeneous pileus which is coriaceous and persistent. *T. terrestris* Ehrh. is designated the type species. *Thelephora,* as envisioned by Fries, included five "tribes" in the genus proper. In addition he listed *Stereum, Phylacteria* and *Leiostroma* as subgenera. Some of these subgroups had been treated as genera by earlier authors, and some of them have since been regarded as worthy of generic ranking.

Other systematists, including Willdenow, Persoon, Link, and Nees, had included *Thelephora* in their systems of classification preceding Fries. But of greater significance are those who since have attempted to define the limits and characteristics of the group. Among the more important of these are Patouillard (1900) and his followers, including Bourdot and Galzin (1927). They recognize *Thelephora* as a genus of their tribe Clavaries, but place many of the species here regarded as belonging to *Thelephora* in the genus *Phylacteria,* one of the subgenera of Fries. On the other hand, they include in *Thelephora* several species which American students refer to *Stereum.*

Burt (1914), whose concept of the genus is followed in this study, characterized *Thelephora* as follows: "Fructifications pileate or clavate, coriaceous; hymenium continuous with the hymenophore and similar to it, inferior, or amphigenous in a few species, even or faintly ribbed or papillose; basidia simple, 4-spored; spores colored, typically muricate but even, or rough-walled in a few species."

The phrase "muricate but even" is not particularly fortunate when applied to *Thelephora,* since all the species have spores which are at least echinulate, and those of many are decidedly irregular in contour, with conspicuous spines or warts.

In general external appearance, and often even in microscopic characteristics, *Thelephora,* especially the upright, narrowly branched species, resembles *Clavaria.* The distinction between

Thelephora and certain species of *Lachnocladium* is even more difficult to define. In fact Patouillard includes *Lachnocladium* in his series of Thelephores. Following Burt, *Clavaria* is here separated from both *Thelephora* and *Lachnocladium* by its fleshy, non-coriaceous texture. Burt would restrict *Lachnocladium* to species with smooth, pale spores, but it may be questioned whether this is practicable.

The various species of *Thelephora,* particularly the erect, much-branched forms, intergrade so closely with one another that it is sometimes impossible to place a specimen into one or another species with complete assurance. In fact, an unbroken series may be established beginning with *T. regularis,* and continuing through *T. multipartita* to *T. anthocephala* and *T. palmata.* Since an abundance of material has been available, the problem has been principally that of attempting to decide where to place the numerous intermediate forms which have appeared.

Thelephora anthocephala and *T. palmata* especially have caused difficulty, and it is with hesitation that they are left as separate species. The "typical" odor of *T. palmata,* which is described by Burt, among others, is not noticeable in our collections except for a pungent odor which seems to be characteristic of all species of *Thelephora* studied. Although distinctive odors have been reported for several species, including *T. palmata*, *T. cuticularis*, and *T. albido-brunnea,* it does not seem possible to accept odor as a distinguishing characteristic. In fact the great number of times that odors have been attributed to various species suggests that this is a generic, rather than specific, characteristic. None of the specimens which were examined had a distinctive odor either when fresh or dry.

The character of the hymenium, another basis for separating *T. anthocephala* from *T. palmata,* likewise is difficult to determine, since it frequently may be inferior on part of the pileus and amphigenous on the remainder of the same pileus. Thus it is often with doubt that a collection is included in one or the other species on this basis. Size, too, seems practically worthless in attempting to distinguish between the two species, if they are separate species. Color is not a good criterion for species distinction among any of these forms, since it is likely to change with age and with conditions of growth.

Burt says that, in his opinion, *T. multipartita* is a variety of *T. regularis.* Many of our collections of *T. multipartita* also contain specimens which, if separated from the remainder of the collection, would certainly be identified as *T. anthocephala;* nevertheless, the four separate groups have been retained here, though with some doubt whether there may be more than two distinct species.

Emmons (1927) reported six species from Iowa: *anthocephala, multipartita, regularis, albido-brunnea, terrestris,* and *griseozonata. T. terrestris,* as he reported it, included forms which are here referred to *T. intybacea.* The remaining five species are here maintained in the same sense as in his treatment, and five additional species are included.

In the key to the species which follows, an attempt has been made to define the species as distinctly as possible, but it is difficult to present a workable key to a genus having the overlapping and intermediate forms which are found in *Thelephora.* The colors used in the key, and in the descriptions, are based on Ridgway, Color Standards and Nomenclature.

This study was suggested by Professor G. W. Martin and completed under his direction in the mycological laboratory of the State University of Iowa.

Key to the species of *Thelephora*

a. Pileus effused or incrusting, sometime resupinate when young, eventually with free branches or lobes .... b
a. Pileus entirely free, erect, not effused nor incrusting .... h
  b. Few to many slender, divided branches present c
  b. Free portion composed of pileate lobes, not divided .... d
c. Incrusting and ascending small plants; free branches few to many, with blunt or fimbriate tips .... 1. *T. fimbriata*
c. Effused and incrusting surface litter; free branches numerous, with penicillate tips .... 2. *T. spiculosa*
  d. Hymenium drab, becoming sage green in KOH .... 3. *T. cuticularis*
  d. Hymenium pallid to ferruginous or fuscous, not becoming sage green in KOH .... e
e. Pileus soft, spongy, isabelline, becoming darker only with age, more than 2 mm. thick .... 4. *T. albido-brunnea*
e. Pileus subcoriaceous to coriaceous, usually darker than isabelline, less than 2 mm. thick .... f
  f. Pileus zonate .... 5. *T. griseozonata*
  f. Pileus not zonate .... g
g. Pileus with drab or fuscous shades, fibrous-squamulose, with fibers matted to form appressed and completely adnate squamules; margin entire .... 6. *T. intybacea*

g. Pileus with ferruginous shades, fibrous-squamulose and usually strigose, the squamules not appressed; margin fibrous-fimbriate . . . . 7. *T. terrestris*

  h. Pileus infundibuliform, entire or becoming tardily divided into a few broad lobes . . . . 8. *T. regularis*

  h. Pileus divided into lobes or branches from early stage . . i

i. Branches flattened or flabellate, but retaining infundibuliform arrangement, especially at base of branches . . . . . . 9. *T. multipartita*

i. Branches slender, numerous, not suggesting infundibuliform arrangement . . . . . j

  j. Branches terete; hymenium amphigenous; stipe smooth or nearly so . . . 10. *T. palmata*

  j. Branches somewhat flattened; hymenium mostly inferior; stipe villose . . . 11. *T. anthocephala*

1. THELEPHORA FIMBRIATA Schw. Trans. Amer. Phil. Soc. n. s. 4:166. 1834. *Merisma fimbriatum* Schw. Schrift. Naturf. Ges., Leipzig, 1:110. 1822. *Thelephora scoparia* Peck, Rep. N. Y. State Mus. 42:123(27). 1889.

Fig. 1.

Fructification coriaceous, united below, and incrusting and ascending twigs and small plants up to 4 cm., with free branches or branch tips 2-10 mm. long, fimbriately incised, brownish drab to snuff brown; hymenium even, pruinose-pubescent; spores umbrinous, irregular, echinulate, 8-9 x 5.5-6.5μ.

Thelephora fimbriata resembles the erect species of *Thelephora* rather closely, except that its axis is always some twig or small plant. It approaches *T. spiculosa*, but is distinguished from it by having fimbriate instead of penicillate, spiked branch tips, and by its ascending habit of growth, rather than the effused, reclinate habit of *T. spiculosa*.

TYPE LOCALITY: Salem, North Carolina.

SPECIMENS EXAMINED: Iowa: Iowa City.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Fig. 3. 1914.

2. THELEPHORA SPICULOSA Fries, Syst. Myc. 1:434. 1821.

Fig. 4.

Fructification coriaceous to fleshy coriaceous, effused and reclining over surface litter, caespitose, at times somewhat incrusting, up to 10 mm. high and 2 cm. broad; branches usually free, up to 1 cm. long, reclinate, penicillate-tipped, vinaceous-buff to Natal brown; hymenium pruinose granular; spores umbrinous, irregular, echinulate, 6.5-10 x 5-6.5μ.

Thelephora spiculosa commonly appears as a cluster of spiculose-tipped branches, effused, reclining, and sometimes incrusting decaying leaves or other surface litter. It somewhat resembles a much branched, non-erect specimen of *T. multipartita* in general appearance. It may be distinguished from *T. fimbriata* by its spiculose branch tips, and by usually not having a twig or other small supporting structure for a central axis. One specimen is effused and matted over moss, and has few free branches; thus the fructification is so untypical that it is with some doubt that it is referred to *T. spiculosa.*

TYPE LOCALITY: Sweden.
SPECIMENS EXAMINED: Iowa: Iowa City.
ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Fig. 2. 1914.

3. THELEPHORA CUTICULARIS Berk. Lond. Jour. Bot. 6:324. 1847.

Fig. 2.

Fructification coriaceous-spongy, 1 mm. thick, incrusting and ascending twigs, confluent up to 8 cm., sending out free lobes up to 1 cm. long at intervals; surface soft, silky, fibrillose; hymenium inferior, concave, even, drab to drab brown; spores umbrinous, usually flattened on one side, echinulate, 8-10 x 6-7μ.

Thelephora cuticularis may be identified by its drab hymenium, which turns green when crushed in KOH solution. The spores have very slender spines and are usually flattened on one side, thus permitting them to be distinguished from the irregular, angular spores of other species. The odor mentioned by Burt was not noticeable even when our specimens were collected.

TYPE LOCALITY: Waynesville, Ohio.
SPECIMENS EXAMINED: Iowa: Iowa City.
ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Fig. 2. 1914.

4. THELEPHORA ALBIDO-BRUNNEA Schw. Trans. Amer. Phil. Soc. n. s. 4:166. 1834.

Stereum Micheneri B. & C. Grevillea 1:162. 1873.
Stereum spongiosum massee, Journ. Linn. Soc. Bot. 27:172. 1890.
Thelephora odorifera Peck, Rep. N. Y. State Mus. 44:132(22). 1891.

Fig. 3

Fructification coriaceous-spongy, dimidiate, effused-reflexed, usually imbricate, encircling, incrusting, and ascending up to 12 cm., with numerous free lobes, up to 2 cm. long, usually at least 2 mm. thick; surface fibrous-tomentose; hymenium inferior, even, isabelline to cinnamon brown; spores deep olive buff, irregular, verrucose-echinulate, 8-10.5 x 6-8μ.

Thelephora albido-brunnea is distinguishable by its spongy pileus, which is thicker than that of the other dimidiate and reflexed species of *Thelephora. T. albido-brunnea* was called *T. odorifera* by Peck because of the fragrant odor which he thought to be distinctive for the species. Burt did not notice any special odor in his collections.

TYPE LOCALITY: Bethlehem, Pennsylvania.
SPECIMENS EXAMINED: Iowa: Iowa City, Pine Hollow, West Okoboji, Dubuque County; Michigan: Ann Arbor.
ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 5, Fig. 18. 1914.

5. THELEPHORA GRISEOZONATA Cooke, Grevillea 19:104. 1891.

Fig. 8.

Fructification coriaceous, caespitose, pileoli extended into a short sublateral stem, imbricate, applanate, single pilei up to 3 cm. long and 5 cm. broad; surface silky strigose, with hairs closely appressed to pileus in concentric layers to form alternating zones of Rood's brown and light buff; hymenium inferior, rugose, Rood's brown; spores pale fuscous, rounded to irregular, verrucose-echinulate, 8-10 x 6-8μ.

Thelephora griseozanata is distinguishable from *T. terrestris* by its zonate pileus. The paraphyses are sparingly branched, and divided by septa into short cells.

SPECIMENS EXAMINED: Iowa: Turkey Creek.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 5, Fig. 12. 1914.

6. THELEPHORA INTYBACEA Fries, Syst. Myc. 1:431. 1821.

Fig. 9.

Fructification coriaceous-soft, up to 8 cm. in diameter; single pilei up to 3 cm. long, 4 cm. broad, and 1 mm. thick; surface of strigose, wholly adnate squamules; margin entire; hymenium inferior, papillose; spores snuff brown, angular-tuberculate, 8-10 x 6.5-8.5μ.

Thelephora intybacea is closely related to *T. terrestris*, but the characteristic squamules are completely adnate, instead of free as in the latter. The pileus of *T. intybacea* has an entire margin, while that of *T. terrestris* has a fimbriate margin.

SPECIMENS EXAMINED: Iowa: Iowa City.

EXSICCATI: Ellis and Everhart, North American Fungi, 2732.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 5, Fig. 11. 1914.

7. THELEPHORA TERRESTRIS Fries, Syst. Myc. 1:431. 1821.

Thelephora caryophyllea var. *laciniata* Pers. Myc. Eur. 1:12. 1822.

Thelephora laciniata Fries, Syst. Myc. 1:431. 1821.

Fig. 5.

Fructification coriaceous-soft, effused over and growing up from fallen leaves and twigs, often incrusting, up to 3 cm. high and 5 cm. broad; lobes 1 mm. thick, surface of strigose, free squamules, margin fimbriate; hymenium inferior, papillose; spores pale fuscous, tuberculate, 6.5-8 x 6-7μ.

Thelephora terrestris is distinguished from *T. intybacea* by its free, strigose squamules and fimbriate margin. The clusters of *T. terrestris* often grow from a central stipe to form a cone shaped fructification. Usually several fructifications are adherent, and frequently leaves and twigs are incrusted and included in the group of pileoli.

SPECIMENS EXAMINED: Iowa: West Okoboji; Minnesota: Elbow Lake; Latvia: Riga; Germany.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 5, Fig. 10. 1914.

8. **THELEPHORA REGULARIS** Schw. Schrift. Naturf. Ges., Leipzig. 1:105. 1822.

Thelephora Ravenelii Berk. Grevillea 1:148. 1873.

Fig. 6.

Fructification coriaceous, solitary, erect, infundibuliform, or divided into a few lobes, but still retaining the general funnel shape, up to 2 cm. high and 1.5 cm. broad, vinaceous buff to fawn color; hymenium smooth, pruinose-pubescent; spores melleus to umbrinous, angular-verrucose, 7-8 x 6-7μ.

Thelephora regularis is characteristically infundibuliform and without lobes or branches, but often once or twice divided. If the divisions are more numerous, the specimen must then be classified as *T. multipartita*. Because of the close relationship of the two species, it is easy, and also logical, to conclude that they probably are different growth forms of the same species. At least the numerous intergrading forms show that there is no very fundamental difference between the species.

TYPE LOCALITY: Salem, North Carolina.

SPECIMENS EXAMINED: Iowa: Iowa City, Estherville.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Figs. 6 and 7b. 1914.

9. **THELEPHORA MULTIPARTITA** Fries, Elenchus Fung. 1:166. 1828.

Figs. 7 and 10.

Fructification coriaceous, erect, generally infundibuliform, but with several flabellate lobes, up to 4 cm. high and 2.5 cm. broad, cinnamon brown to pallid; hymenium pruinose, spores umbrinous, angular-verrucose, echinulate, 8-10 x 6.5-7μ. *Thelephora multipartita* is closely related to both *T. regularis* and *T. anthocephala*. It is separated from the former by having more numerous flabellate divisions of the pileus, and from the latter by not being abundantly and finely divided.

TYPE LOCALITY: Island of Lehigh River, Pennsylvania.

SPECIMENS EXAMINED: Iowa: Iowa City.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Fig. 7a. 1914.

10. **THELEPHORA PALMATA** Fries, Syst. Myc. 1:432. 1821.

Merisma foetidum S. F. Gray, Brit. Plants, 1:654. 1821.

Merisma palmatum Duby, Bot. Gall. 2:766. 1830.

Thelephora palmata americana Peck, Rep. N. Y. State Mus. 53:857. 1900.

Fructification coriaceous-soft, erect, up to 6 cm. high and 6 cm. broad; pileus much divided into slender branches, sometimes terete, sometimes slightly dilated and flattened at the ends, chestnut brown; hymenium amphigenous, smooth, pubescent; spores pale umbrinous, echinulate, 8-10 x 6-8.5μ.

Thelephora palmata is distinguished from *T. anthocephala* mainly by its amphigenous hymenium. This is not always an easy character to determine because of the gradations between inferior and amphigenous. *T. palmata* also has slightly larger spores, which are paler than the umbrinous spores of *T. anthocephala.* There may be a tendency for *T. palmata* to be slightly larger than *T. anthocephala.* But this character, like the rest, is not too dependable.

SPECIMENS EXAMINED: Iowa: Iowa City, Estherville; China: Anhwei, Chiu-hua-shan; Latvia: Riga.

ILLUSTRATIONS: Burt, Ann. Mo. Gard. 1:Pl. 4, Fig. 4. 1914.

11. THELEPHORA ANTHOCEPHALA Fries, Syst. Myc. 1:433. 1821.

Merisma anthocephalum Duby, Bot. Gall. 2:766. 1830.

Fig. 11.

Fructification coriaceous, erect, up to 5 cm. high and 3 cm. broad; divisions of pileus numerous, slender, often slightly dilated and quite pubescent at the ends; hymenium inferior, smooth, pubescent, cinnamon brown; spores umbrinous, verrucose-echinulate, 6.5-10 x 5-8μ.

Thelephora anthocephala includes a wide range of forms between *T. multipartita* and *T. palmata.* Its pileus is more abundantly divided than that of *T. multipartita,* but there is little other difference between the two species. *T. anthocephala* is separated from *T. palmata* by three rather doubtful characteristics. *T. palmata* supposedly is larger than *T. anthocephala,* has a distinctive odor, and an amphigenous hymenium as distinguished from the inferior hymenium of *T. anthocephala.* Size seems to be of comparatively little significance in distinguishing the species of this genus. Whether *T. palmata* may be distinguished by its odor is very debatable. And while the distinction between amphigenous and inferior hymenium would seem to be a good characteristic, this also is subject to question. The broad, flat lobes of a pileus almost invariably have an inferior hymenium, while terete lobes may have either an inferior or amphigenous hymenium. The principal feature which casts doubt upon the validity of *T. palmata* as a species distinct from *T. anthocephala* is the occurrence of both an inferior and an amphigenous hymenium upon the various divisions of a single pileus. Often it is with considerable difficulty that a collection may be placed in one species or the other.

SPECIMENS EXAMINED: Iowa: Iowa City, Big Grove.

ILLUSTRATIONS: Burt, Ann. Mo. Bot. Gard. 1:Pl. 4, Fig. 1. 1914.

STATE UNIVERSITY OF IOWA
IOWA CITY

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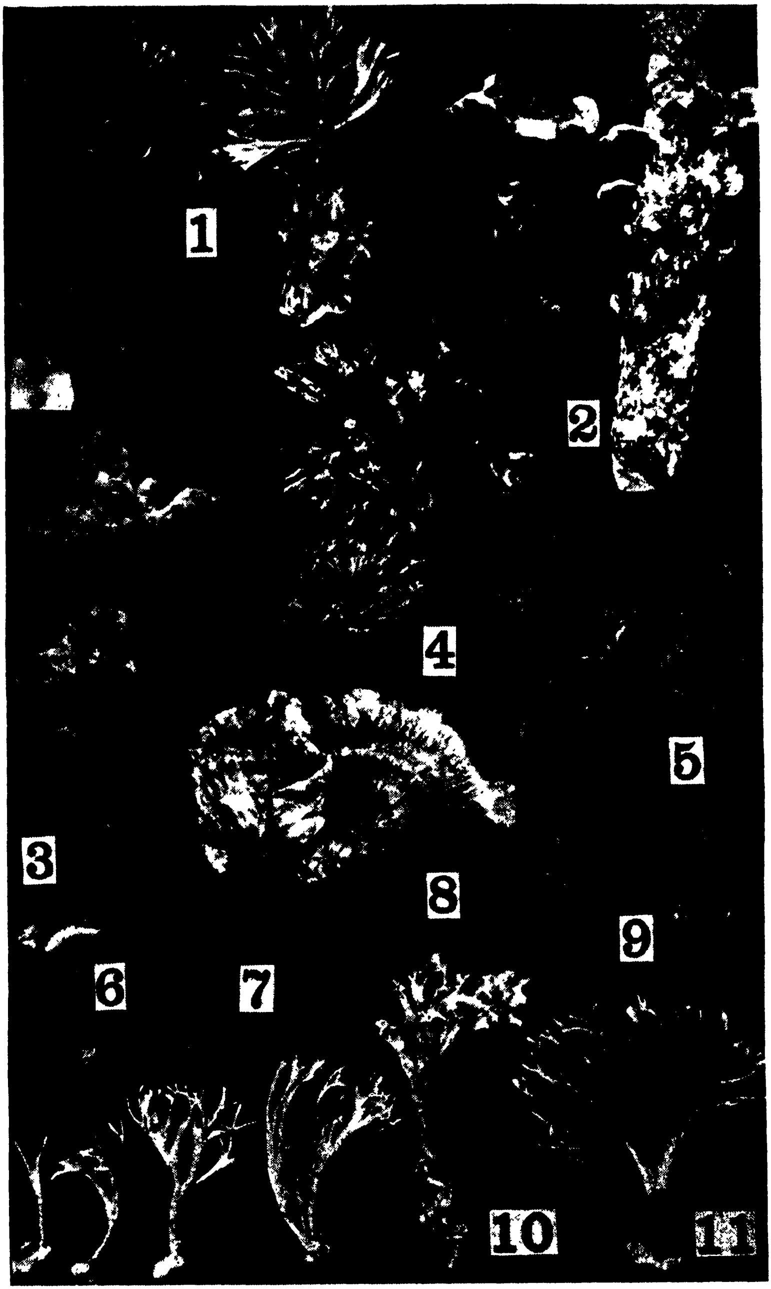
EXPLANATION OF PLATE

Fig. 1. Three specimens of *Thelephora fimbriata.*
Fig. 2. Two specimens of *T. cuticularis.*



Explanation of Plate Continued

Fig. 3. *T. albido-brunnea.*
Fig. 4. *T. spiculosa.*
Fig. 5. *T. terrestris.*
Fig. 6. *T. regularis.*
Fig. 7. *T. multipartita.*

Fig. 8. *T. griseozonata.*

Fig. 9. *T. intybacea.*

Fig. 10. Five specimens of *T. multipartita* from a single collection to show forms ranging from typical *T. multipartita* to those approaching *T. anthocephala.*

Fig. 11. *T. anthocephala.*

TYPHULA JUNCEA IN IOWA

MARY LOUISE GRUMBEIN

So far as is known, no species of *Typhula* has heretofore been reported from Iowa. It is of interest, therefore, to record the occurrence of a striking species of this genus. On the rainy afternoon of October 4, 1941, it was discovered fruiting in great abundance on fallen oak leaves in a wooded ravine between North Liberty and Lake Macbride. The pale yellow clubs, 10-12 cm. tall, were developing over an area a hundred feet or more in length and twenty or thirty feet in width in such profusion that in places they suggested patches of yellow grass blades.

A second trip to the same locality was made a week later, but few specimens were found and these were old and withered and would scarcely have been noted had it not been for the earlier collection. It is not unlikely that the fungus appears only during rainy weather late in the season, and that this may account for the lack of previous collections.

The species proved to be *Typhula juncea* (Fries) Karst. of Coker's (1923) treatment. Coker cites specimens from New York, New Hampshire, West Virginia and California. Burt (1922), using the older name *Clavaria juncea* Fries, gives the distribution as from New England to Michigan and Missouri, mentioning its abundance in the vicinity of St. Louis. Remsberg (1940), in a recent study of the genus *Typhula* based largely on laboratory cultures, reduces *T. juncea* to synonymy with *T. phacorrhiza,* which she designates as the neo-type of the genus. She makes the presence of sclerotia diagnostic for the genus. Coker separates *T. juncea* from *T. phacorrhiza* largely on the absence of sclerotia in the former species and their presence in the latter. Remsberg admits that the basidiocarps of the forms she includes in *T. phacorrhiza* may sometimes arise directly from the mycelium, but the implication is that this is exceptional.

Careful examination of the abundant material of the Iowa collection reveals no trace whatsoever of a sclerotium and the inference is that it does not occur in this form as it grows naturally, although it is of course possible that sclerotia might be formed in culture. Under the circumstances it seems desirable to refer the specimens to *T. juncea* and to regard the supposed synonymy of that species with *T. phacorrhiza* as doubtful until further evidence is submitted.

Burt speaks of the acrid taste of his specimens. This was not apparent in the Iowa material.

DEPARTMENT OF BOTANY
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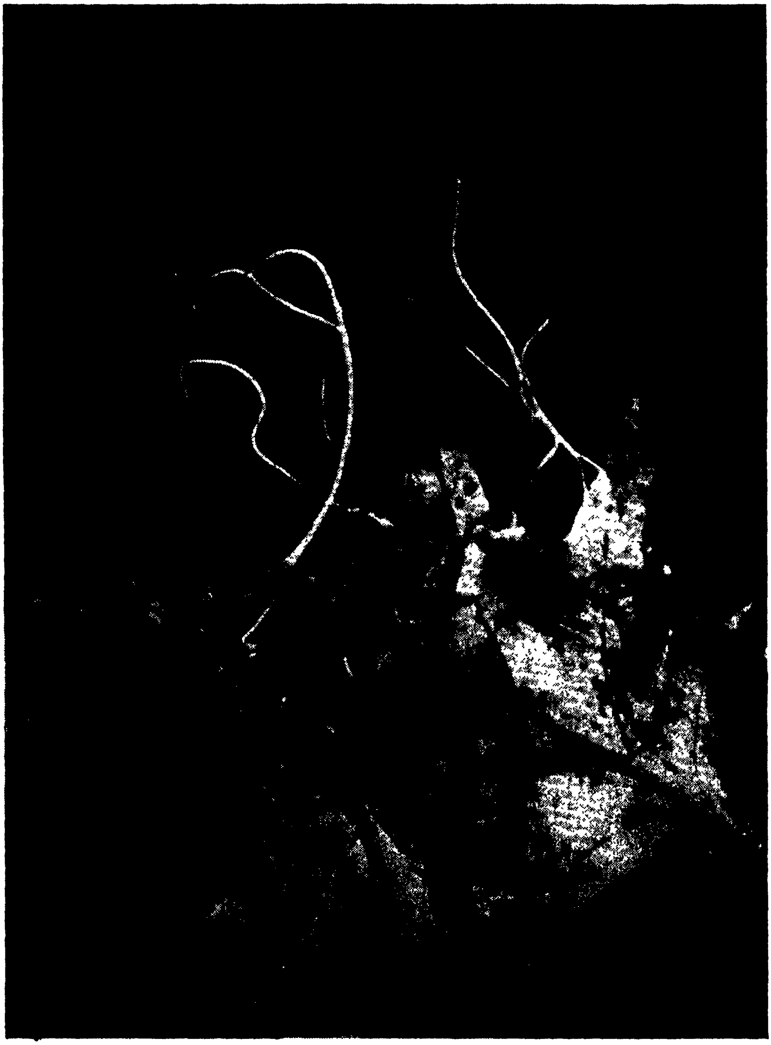

Fig. 1. *Typhnla juncea* on oak leaves.

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SLIME MOLDS OF BENZIE COUNTY, MICHIGAN

RUTH GILMAN

This species list of the slime molds of Benzie County, Michigan represents the forty-two species collected by the author in the Birch-beech-maple-hemlock woods on the north shore of Crystal Lake. Practically all the specimens were collected either in June, 1936, or during June and July, 1939, when the ground is very moist.

The two species of *Badhamia* are especially notable; *Badhamia populina* is recorded for the first time east of Colorado; *Badhamia panicea* is recorded for the first time east of the Mississippi River.

The author wishes to express her thanks to J. C. Gilman for his help in collecting and identifying the specimens, to H. S. Conard, for his help in identifications, and to T. E. Brooks for checking all of the identifications.

All names are according to the keys and descriptions of *THE MYXOMYCETES*, Macbride and Martin (1934), and are given below as they occur in that volume. Those species marked with an asterisk are recorded from Michigan for the first time.

Ceratiomyxaceae
  Ceratiomyxa fruticulosa (Muell.) Macbr.

Physaraceae
  Fuligo septica (L.) Weber
  **Badhamia populina* Lister
  **B. panicea* (Fr.) Rost.
  Physarum virescens Ditmar var. *nitens* Lister (P. *luteolum* Peck)
  P. confertum Macbr.
  P. bivalve Pers.
  P. contextum Pers.
  P. globuliferum (Bull.) Pers.
  P. pulcherrimum Berk & Rav.
  **P. oblatum* Macbr.
  P. nutans Pers.
  P. viride (Bull.) Pers.
  Craterium leucocephalum (Pers.) Ditm.
  Leocarpus fragilis (Dickson) Rost.

Didymiaceae
  Didymium squamulosum (Alb. & Schw.) Fr.
  D. melanospermum (Pers.) Macbr.
  D. floriforme (Bull.) Pers.

Stemonitaceae
- *Stemonitis fusca* Roth
- *S. axifera* (Bull.) Macbr.
- *S. flavogenita* Jahn
- *Comatricha nigra* (Pers.) Schroet.
- *C. typhoides* (Bull.) Rost.

Lamprodermaceae
- *Enerthenema papillatum* (Pers.) Rost.
- *Lamproderma arcyrionema* Rost.

Cribrariaceae
- *Cribraria argillacea* Pers.
- *C. dictydioides* Cooke & Balf.
- **C. languescens* Rex
- **C. piriformis* Schrad.
- *Dictydium cancellatum* (Batsch) Macbr.

Tubiferaceae
- *Tubifera ferreginosa* (Batsch) Gmelin.

Lycogalaceae
- *Lycogala epidendrum* (L.) Fr.

Perichaenaceae
- **Perichaena corticalis* (Batsch) Rost.

Arcyriaceae
- *Arcyria nutans* (Bull.) Grev.
- *A. incarnata* Pers.
- *A. cinerea* (Bull.) Pers.
- *A. denudata* (L.) Wettstein

Trichiaceae
- *Trichia scabra* Rost.
- *T. favoginea* (Batsch) Pers.
- *Hemitrichia vesparium* (Batsch) Macbr.
- *H. clavata* (Pers.) Rost.
- *H. stipitata* (Massee) Macbr.

* represents species recorded from Michigan for the first time.

GRINNELL COLLEGE,
GRINNELL, IOWA

THE LIVERWORTS OF IOWA

HENRY S. CONARD

The collections of moss plants from the State of Iowa have been examined to such an extent that we feel warranted in making a statement of our present knowledge of the species of liverworts and their distribution in the State. While many collections of true mosses have not yet been examined, all of the packets known to contain liverworts have been studied, so far as known to us. It seems unlikely that any additional species will appear in the collections already made. Probably a few extensions of range will be found. This report will indicate the lacunæ in our knowledge of distribution and the places where extensions of range may be expected. Where a species is absent from one county, but is known from all of the surrounding counties it is reasonably certain that it will be found in suitable places within the county for which it is not yet reported.

In 1884 Professor C. E. Bessey listed some hepatics "within a radius of twenty miles of Ames, Iowa." Dr. Fitzpatrick in 1897 listed eleven species from southern Iowa. Professor Shimek in 1898 reported twenty-one species of "Iowa Liverworts." Occasional mention of species has been made in various other papers. In 1940 Conard distributed "Thirty Iowa Liverworts" to ten herbaria, as reported in the proceedings of the Iowa Academy. The present paper recognizes fifty-four species.

Some of the species referred to by former writers, we have been unable to find in the field or in the collections. These are disposed of as follows:

Porella pinnata, Jackson Co. (Shimek, 1898), is omitted. A specimen from Johnson Co. labeled *P. pinnata* proves to be *P. platyphylla.*

Jungermannia ventricosa, reported by Shimek (1898) for Johnson and Webster Counties, is omitted. Until found, we regard it as a mistaken identity. The specimen from Muscatine Co. "on *Anthoceros*" (Shimek, 1898) has been examined and is *Lophocolea heterophylla.*

Cephalozia multiflora reported by Fitzpatrick (1897a) is omitted.

Cephaloziella divaricata reported by Conard (Blagg, 1930) is probably *C. byssacea.*

Lejeunea serpyllifolia americana reported by Fitzpatrick (1897b) for Johnson County is probably *Radula complanata.*

Ptilidium ciliare, Johnson Co. (Shimek, 1898), "not rare," is probably *P. pulcherrimum.*

Riccia crystallina reported by Fitzpatrick (1897b) from Johnson and Decatur Counties was probably *R. beyrichiana.*

Riccia glauca reported by Bessey (1884) is omitted.

In the following list, herbarium specimens are indicated by letters:

a, specimens distributed in Thirty Iowa Liverworts.
b, specimen in Grinnell College Herbarium.
c, specimen in State University Herbarium.

Where no specimen is available, the report is cited in parentheses. The numbers following the names indicate the counties in which the species has been found. The counties are numbered according to the map, Fig. 1, for which I am indebted to Professor H. E. Jaques of Iowa Wesleyan College. The expression 2-4 means that the species has been found in counties 2, 3, and 4.

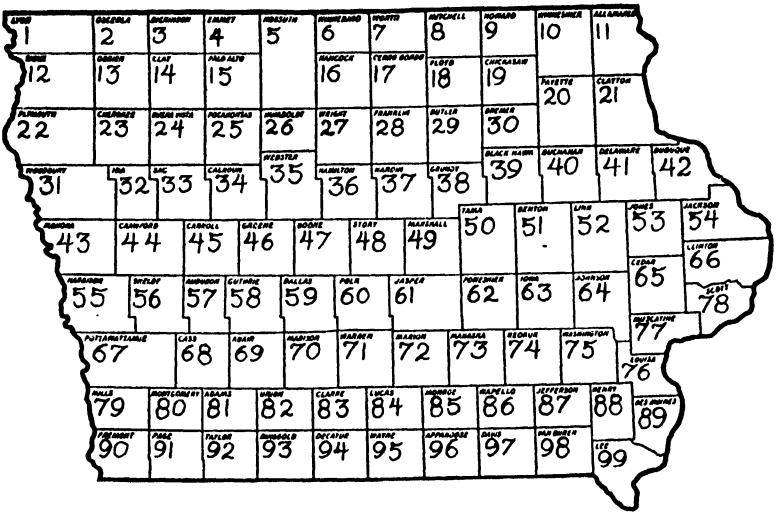

Fig. 1. County map of Iowa with numbers as used in the text.

In recording occurrences by counties, we recognize the inadequacy of the use of political areas for describing the distribution of plants. The county unit is used solely for convenience. When the plant associations of the State have been identified, described, and located, the distribution of all plants, and animals as well, can be adequately stated.

THE LIST

1. *Anthoceros laevis* L. abc, 4, 9, 10, 21, 37, 48 (Bessey, 1884), 52, 55, 61-63, 64 (Fitzpatrick, 1897), 65, 72-74, 77, 86, 99.
2. *A. punctatus* L. b, 10, 62, 63, 77 (Shimek, 1898), 86.
3. *A. punctatus crispulus* Mont. b, 62.

4. *Bazzania trilobata* (L) S. F. Gray b, 21.
5. *Blasia pusilla* L. abc, 21, 30, 41, 52, 61-64, 71, 72, 77.
6. *Blepharostoma trichophyllum* (L) Dumort. bc, 11, 21, 77.
7. *Calypogeia fissa* (L) Raddi b, 99.
8. *C. Trichomanes* (L) Corda bc, 72, 77.
9. *Cephalozia connivens* (Dicks.) Lindb. abc, 42, 52, 77.
10. *C. media Lindb.* bc, 53, 77.
11. *Cephaloziella byssacea* (Roth.) Warnst. b, 10, 11, 21, 61, 62, 77, 86.
12. *C. Hampeana* (Nees)Schiffn. b, 74.
13. *Chiloscyphus fragilis*(Roth)Schiffn. b, 10, 11, 39, 71, 73.
14. *C. pallescens* (Ehrh.) Dumort. bc, 20, 41.
15. *C. polyanthus*(L)Corda abc, 3, 10, 11, 35, 37, 47, 50, 61, 64, 77 (Shimek, 1898).
16. *Cololejeunea Biddlecomiae*(Aust.)Evans abc, 8, 10, 11, 21, 42, 53.
17. *Conocephalum conicum*(L)Dummort. abc, 3, 4, 10, 11, 17, 20-22, 31, 35-37, 42, 46, 47, 48 (Bessey), 52, 53, 63, 64 (Shimek), 65, 71-74, 76, 77, 86, 89, 90, 98.
18. *Frullania Bolanderi* Aust. Hb. Wolden. b, 4.
19. *F. eboracensis* Gottsch abc, 1, 4, 6, 8-11, 14, 17, 18, 20, 21, 28-30, 35, 37, 39-42, 47-49, 51-53, 58-68, 70-74, 76, 77, 80-87, 89, 91, 94-99.
20. *F. inflata* Gottsche ab, 3, 4, 6, 7, 11, 14, 15, 25, 53, 54, 60, 63, 67-71, 79-80, 90-92.
21. *F. riparia* Hampe abc, 10, 11, 20-22, 41, 42, 51, 53-54, 59, 64, 65, 70, 73, 74, 89, 94, 95, 98, 99.
22. *F. squarrosa* (R.Bl. & N.)Dumort. bc, 11, 26, 35 (Shimek, 1898), 42, 52-54, 62, 70, 77, 85, 98.
23. *Harpanthus, scutatus* (W. & M.)Spruce bc, 21.
24. *Jamesoniella autumnalis* (DC.)Steph. abc, 8, 10, 11, 20, 21, 37, 62, 72, 77, 86.
25. *Jungermannia lanceolata* L. bc, 21.
26. *Leiocolea badensis*(Gottsche) Joerg. a, 47, 98.
27. *Lepidozia reptans*(L)Dumort. abc, 10, 11, 21, 37, 42, 52 (Drexler).
28. *Lophocolea heterophylla*(Schrad.)Dumort. abc, 4, 5, 8-11, 20, 21, 35, 37, 39-42, 47, 50, 52, 53, 61-64, 68, 71-74, 77, 78, 84, 86, 87, 90, 94, 96-99.
29. *L. minor* Nees. ab, 4, 8, 10, 11, 37, 40-42, 47, 51, 53, 61, 63, 72, 73, 77, 86, 87, 99.
30. *Lunularia cruciata*(L)Dumort. 64 (Fitzpatrick, 1897).
31. *Mannia fragraus* (Balb.)F. & C. abc, 1, 3, 4, 10, 11, 18, 42, 52-54, 64 (Shimek, 1898), 72, 77.
32. *M. pilosa*(Hornem.)F. & C. b, 10.
33. *M. rupestris*(Nees)F. & C. ab, 10.
34. *Marchantia polymorpha* L. abc, 3, 4 (Shimek, 1898), 6, 9-11, 17, 18, 20, 21, 30, 31, 35-37, 41, 42, 46, 50, 52, 53, 62-65, 69, 72, 73, 77, 98.
35. *Notothylas orbicularis*(Schwein.)Sull. ab, 39, 61, 62.
36. *Nowellia curvifolia*(Dicks.)Mitt. b, 86.
37. *Plagiochila asplenioides* (L) Dumort. abc, 4, 6, 8, 10, 11, 20, 21, 37, 41, 42, 47, 48, 50, 52(Drexler), 61-63, 64, (Fitzpatrick, 1897), 65, 70-73, 77.
38. *Plectocolea crenulata gracillima* (Smith) (=Jungermannia gracillima Smith) c, 52.

39. *P. hyalina* (Lyell.)Mitt. abc, 11, 52, 61, 72, 73, 77, 86, 99.
40. *Porella platyphylla* (L)Lindb. bc, 21, 64.
41. *P. platyphylloidea* (Schwein.)Lindb. abc, 4, 8-11, 17, 18, 20, 22, 37, 41, 42, 47, 48, 50-54, 58, 61, 63-65, 70, 72-74, 76, 89, 98, 99.
42. *Preissia quadrata* (Scop.)Nees abc, 10, 11, 20, 21, 35, 47, 42, 47, 52, 53, 77.
43. *Ptilidium pulcherrimum* (Web.)Hampe b, 11, 21, 42, 53.
44. *Radula complanata* (L)Dummort. ab, 9, 11, 21, 42, 62.
45. *Reboulia hemisphaerica* (L)Raddi abc, 1, 10, 11, 20, 21, 30, 35, 37, 41, 42, 46, 47, 50-54, 61, 62, 64-66, 68, 71-77, 89, 90, 96, 98, 99.
46. *Riccardia pinguis* (L)S. F. Gray bc, 3, 4, 62.
47. *Riccia Beyrichiana* Hampe b, 39, 50, 60-62, 77, 96.
48. *R. fluitans* L. abc, 2, 3, 4, 6, 14, 17, 24, 36, 52, 61, 62, 64 (Fitzpatrick, 1897), 76, 78, 99.
49. *R. Frostii* Aust. abc, 1, 4, 39, 50, 60-63, 76.
50. *R. Sullivantii* Aust. abc, 43, 50, 60-62.
51. *Ricciocarpus natans* (L)Corda abc, 3, 4 (Wolden, 1919), 6, 7, 13, 14, 17, 24, 39, 40, 41, 45, 49, 52, 61-64, 70, 73, 76-78, 98.
52. *Scapania nemorosa* (L)Dummort. abc, 21, 72, 77, 86.
53. *Tritomaria exsecta* (Schmid.)Schiffn. abc, 11, 21.
54. *Tritomaria exsectiformis* (Breidl.)Schiffn. b, 10, 21.

GRINNELL COLLEGE,
Grinnell, Iowa

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POSTSCRIPTS -Up to September 15, 1942 the following additions to the list and occurrence of Hepatics in Iowa have been discovered:

Anthoceros laevis 50, 76
A. punctatus 77 (specimen seen)
Cephalozia bicuspidata (L) Dumort. b, c, 64?*, 77
C. media 64?*
Jamesoniella autumnalis 35
Marchantia polymorpha 15
Notothylas orbicularis 15, 50
Ricca Beyrichiana 15
R. Frostii 14

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*This packet in Hb. S.U.I. is labeled Johnson Co. The specimen does not look like Iowa material and I suspect that the label is incorrect.

A PRELIMINARY LIST OF BRYOPHYTES OF LINN COUNTY, IOWA*

R. V. Drexler

In the rather extensive literature on Iowa bryophytes little mention is made of Linn county. Published records, however, do not represent all collecting for Dr. H. S. Conard of Grinnell College has collected fifty species and one variety of mosses and fifteen species of liverworts. Of the above number nine species of mosses and seven species of liverworts have not been collected by the author. This paper is an attempt to bring together under one title the names of bryophytes collected in Linn county.

Considerable collecting has been done by Dr. L. R. Wilson of Coe College and several fine records (*Bruchia Sullivanti* and *Lepidozia reptans*) are due to his activity. Rather extensive collections have been made by the author either alone or in company of members of a class in bryophytes. Some of this material, especially the Brachytheciums and Leskeas, has not been identified with certainty and is not included in this report.

The total known bryophyte flora of Linn county consists of ninety one species and five varieties of mosses and eighteen species of liverworts. In addition there is one species of moss from the literature which is of doubtful validity. One species of moss is not represented in the collections of either Dr. Conard or the author. Nomenclature follows that of Andrews (1940, b), Evans (1940),

The author wishes to thank Dr. H. S. Conard for permission to use his list of Linn county collections and for many other favors too numerous to enumerate. Miss Irma Schnooberger, a student of Dr. W. C. Steere of the University of Michigan, kindly identified the Sphagna.

MUSCI

Sphagnaceae

Sphagnum magellanicum Brid.
Known from but one station in a seepage area on Lindley Fine Sand two miles northwest of Cedar Rapids. Identification confirmed by Miss Schnooberger.

Sphagnum capillaceum (Weiss) Schrank.
Growing near the above but on drier soil. Identified by Miss Schnooberger.

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* Contributions from the Science Laboratories of Coe College N. S. No. 5.

Polytrichaceae

Atrichum angustatum (Brid.) Bry. Eur.
Common on soil in more xeric places than *A. undulatum.*

Atrichum crispum (James) Sull.
From prairie bog three miles south of Coggon. Communicated by Dr. H. S. Conard.

Atrichum Macmillani (Holz.) Frye
On sandy soil in woods northwest of Cedar Rapids.

Atrichum undulatum (Hedw.)
Common on soil in moist woods. Also collected by Dr. Conard.

Polytrichum commune Hedw.
Rather frequent on ground in woods. It is especially common in sandy soil areas.

Polytrichum juniperinum Hedw.
Common, especially on sandy soil.

Polytrichum ohioense Ren. & Card.
Not common. Also collected by Dr. Conard.

Fissidentaceae

Fissidens cristatus Wils.
Not common.

Fissidens minutulus Sull.
Frequent on moist limestone rocks in woods. All material collected was sterile. Also collected by Dr. Conard.

Fissidens taxifolius Hedw.
Common on soil in moist woods. Also collected by Dr. Conard.

Fissidens viridulus (Web. & Mohr) Wahlend.
On soil in prairie bog north of Cedar Rapids.

Ditrichaceae

Bruchia Sullivanti Aust.
Collected in Cedar Rapids by Dr. L. R. Wilson. Dr. Conard checked the identification and informed the author that this is the second recognizable Iowa collection.

Ceratodon purpureus (Hedw.) Brid.
Common. Reported from Cedar Rapids by Savage (1899). Also collected by Dr. Conard.

Ditrichum pallidum (Hedw.) Hampe
Common. Also collected by Dr. Conard.

Ditrichum pusillum (Hedw.) E. G. Britton
Common on soil. Also collected by Dr. Conard.

Pleuridium subulatum (Hedw.) Lindb.
Not frequently collected but probably not rare.

Dicranaceae

Dicranella heteromalla (Hedw.) Schimp.

Dicranella varia (Hedw.) Schimp.
Also collected by Dr. Conard.

Dicranum scoparium Hedw.
Frequent on sandy soil only.

Leucobryaceae

Leucobryum glaucum (Hedw.) Schimp.

Distribution similar to that of *Dicranum scoparium* but more abundant.

Pottiaceae

Barbula fallax Hedw.

Common on clay soil, especially in exposed habitats. Collected by Dr. Conard also.

Barbula unguiculata Hedw.

A weedy species. Collected by Dr. Conard also.

Desmatodon obtusifolius (Schwaegr.) Jur.

Communicated by Dr. Conard.

Desmatodon Porteri James

Collected from crevices in low limestone cliffs along the Cedar River at Palisades State Park.

Gymnostomum calcareum Nees & Hornsch.

Communicated by Dr. Conard.

Phascum cuspidatum Hedw. var. *americanum* Ren. & Card.

Communicated by Dr. Conard.

Tortula mucronifolia Schwaegr.

Communicated by Dr. Conard.

Tortula ruralis (Hedw.) Smith

Communicated by Dr. Conard.

Weisia viridula Hedw.

A weedy species.

Grimmiaceae

Grimmia apocarpa Hedw.

Frequent on rocks but not abundant.

Hedwigia ciliata Hedw.

Has been found on erratic granite boulders only.

Funariaceae

Funaria hygrometrica Hedw.

Common. Also collected by Dr. Conard.

Physcomitrium accuminatum (Schleich.) Bry. Eur.

Reported from Cedar Rapids by Savage (1899) as *P. accuminatum* Br. & Schimp. Savage specimen not seen.

Physcomitrium turbinatum (Mx.) Brid.

Common on clay soil. Probably the only species of *Physcomitrium* to be found in Linn County. Also collected by Dr. Conard

Orthotrichaceae

Orthotrichum pumilum Dicks.

From bark of an American Elm growing in forest northwest of Cedar Rapids.

Orthotrichum strangulatum Schwaegr.

On rocks. Communicated by Dr. Conard.

Timmiaceae

Timmia megapolitiana Hedw.

On soil and moist limestone in woods. Some of the material has broad leaves and is referred to the variety *cucullata*. Also collected by Dr. Conard.

Aulacomniaceae

Aulacomnium heterostichum (Hedw.) Bry. Eur.

Common on moist banks in woods.

Aulacomnium palustre (Web. & Mohr) Schwaegr.

Common in boggy pastures. Reported by Cavanaugh (1929) as *A. palustre* Schwaegr. Collected by Dr. Conard in bog south of Coggon.

Bartramiaceae

Bartramia pomiformis Hedw.

Frequent on moist banks with *Aulacomnium heterostichum.*

Bryaceae

Byrum argenteum (L.) Hedw.

Common in exposed habitats. Also collected by Dr. Conard.

Bryum caespiticum (L.) Hedw.

On soil, especially exposed road cuts. Also collected by Dr. Conard.

Bryum cuspidatum (Bry. Eur.) Schimp.

Reported from Cedar Rapids by Savage (loc. cit.) as *B. intermedium* Brid. Andrews (1940, a) writes that *B. intermedium* (Ludw.) Brid. is a European species credited to America by early bryologists because, at that time, *B. cuspidatum* had not been segregated from *Bryum bimum* Schreb. The author has not seen Savage's collection.

Pohlia nutans (Hedw.) Lindb.

Common.

Pohlia Wahlenbergii (Web. & Mohr) Andrews

Frequent in wet habitats. Also collected by Dr. Conard.

Rhodobryum roseum (Bry. Eur.) Limpr.

On soil and in rock crevices in deep woods. Also collected by Dr. Conard.

Mniaceae

Mnium affine Bland.

Common in woods. Also collected by Dr. Conard.

Mnium cuspidatum Hedw.

A common species on a variety of substrata in woods. Also collected by Dr. Conard.

Mnium orthorhynchum Brid.

Communicated by Dr. Conard.

Mnium serratum Brid.

Collected at Palisades State Park on low cliffs and on soil in woods. Similar to the last but with larger leaf cells whose walls are thickened at the corners.

Mnium stellare Hedw.

Collected on bank of small creek in a deep, forested ravine northwest of Cedar Rapids.

Hypnaceae

Climaceae

Climacium americanum Brid.

Collected only at Chain Lakes on wet, sandy soil in woods.

Brachytheciae

Brachythecium oxycladon (Brid.) Jaeger & Sauerb.

Common on soil. Also collected by Dr. Conard.

Bryhnia graminicolor (Brid.) Grout
Frequent on soil and on moist limestone in woods. Also collected by Dr. Conard.

Chamberlainia accuminata (Hedw.) Grout.
Frequent on logs and tree bases in woods. Also collected by Dr. Conard.

Chamberlainia cyrtophylla (Kindb.) Grout
On logs in woods.

Eurhynchium hians (Hedw.) Jaeger & Sauerb.
Frequent on soil in shaded and partly shaded habitats. Seldom in fruit. Also collected by Dr. Conard.

Eurhynchium serrulatum (Hedw.) Kindb.
Frequent in moist shaded habitats. Also collected by Dr. Conard.

Amblystegiae

Amblystegium Juratzkanum Schimp.
On soil and logs in moist woods. Also collected by Dr. Conard.

Amblystegium serpens (Hedw.) Bry. Eur.
Frequent on rotten wood in moist habitats.

Amblystegium varium (Hedw.) Lindb.
Frequent in moist habitats. Some of the material collected is the variety *parvulum* (Aust.) Mitt.

Calliergonella cuspidata (Brid.) Loeske.
Common on a wet prairie north of Cedar Rapids.

Campylium chrysophyllum (Brid.) Bryhn.
On rotten wood in moist habitats.

Campylium hispidulum (Brid.) Mitt.
On rotten wood in moist habitats. Also collected by Dr. Conard.

Drepanocladus aduncus (Hedw.) Warnst.
Common in wet prairie north of Cedar Rapids.

Hygroamblystegium irriguum (Wils.) Loeske.
Frequent on rocks in stream beds. Also collected by Dr. Conard.

Hygroamblystegium orthocladon (Beauv.) Grout
On rocks in stream beds.

Leptodictyum riparium (Hedw.) Warnst.
Frequent on soil and logs in wet habitats. Some of the Linn County material is the variety *abbreviatum* (Bry. Eur.) Grout.

Leptodictyum trichopodium (Schultz) Warnst.
This species and its variety *Kochii* (Bry. Eur.) Broth. communicated by Dr. Conard.

Hylocomieae

Rhytidiadelphus triquetrus (Hedw.) Warnst.
Collected from *Polytrichum jumiperinum* mat at Chain Lakes.

Hypneae

Homomallium adnatum (Hedw.) Broth.
On rocks in woods.

Hypnum Patientiae Lindb.
Frequent on logs and on ground. Also collected by Dr. Conard.

Pylaisia Selwynii Kindb.
Probably common on tree trunks.

Platyggyrium repens (Brid.) Bry. Eur.
Common on logs; trees, sometimes high on the trunks; and logs in woods. Also collected by Dr. Conard.

Plagiothecieae

Plagiothecium deplanatum (Sull.) Grout
Frequent in moist woods. Also collected by Dr. Conard.

Plagiothecium Roeseanum (Hampe) Bry. Eur.
On soil in moist woods.

Entodonteae

Entodon cladorrhizans (Hedw.) C. Müll.
Frequent on logs in woods.

Entodon compressus (Hedw.) C. Müll.
Frequent on tree bases in woods.

Entodon seductrix (Hedw.) C. Müll.
Frequent on logs in woods. Also collected by Dr. Conard. The variety *tenuis* Grout, was collected about five feet from the ground on the trunk of an American Elm growing in a deep, wooded ravine northwest of Cedar Rapids. Dr. Conard identified this material. To the authors knowledge this variety has not been reported for Iowa previously.

Leskeaceae

Anomodon attenuatus (Hedw.) Hüben
Frequent on tree bases and limestone rocks in woods, occasionally on soil. Also collected by Dr. Conard

Anomodon minor (Beauv.) Lindb.
Frequent on tree bases and limestone rocks in woods. Also collected by Dr. Conard.

Anomodon rostratus (Hedw.) Schimp.
Frequent in moist woods on tree bases, on limestone rocks, and on soil. Also collected by Dr. Conard.

Helodium paludosum (Sull.) Aust.
Collected by Dr. Conard in bog south of Coggon.

Leskea gracilescens Hedw.
Common on tree bases. Also collected by Dr. Conard.

Lindbergia brachyptera (Mitt.) Kindb., var. *Austinii* (Sull.) Grout
On tree bases in woods. Probably not common. Also collected by Dr. Conard.

Thelia asprella Sull.
Probably frequent on tree bases in woods. Conard (1938) reports that it is found on white oaks especially. Also collected by Dr. Conard.

Thuidium delicatulum (Hedw.) Mitt.
On logs in woods. Not frequent.

Thuidium pygmaeum Bry. Eur.
Frequent with *Fissidens minutulus* on limestone rocks in deep, forested valleys at Palisades State Park.

Thuidium recognitum (Hedw.) Lindb.
Also collected by Dr. Conard.

Thuidium virginianum (Brid.) Lindb.

On logs, not frequent. Also collected by Dr. Conard. This species, in Iowa, seems to merge into *T. microphyllum.* Also collected by Dr. Conard.

HEPATICAE

Lepidoziaceae

Lepidozia reptans (L.) Dumort.

Collected at Chain Lakes by Dr. L. R. Wilson.

Cephaloziaceae

Cephalozia connivens (Dicks.) Lindb.

Reported from Linn county by Conard (1940) as *C. connivens* (Dicks.) Spruce.

Harpanthaceae

Lophocolea heterophylla (Schrad.) Dumort.

In moist woods on rotten wood and at times on soil. The most common leafy liverwort.

Jungermanniaceae

Plectocolea crenulata (Smith) Evans, var. *gracillema*

Collected by Dr. Conard in bog south of Coggon. Conard (1942)

Plagiochilaceae

Plagiochila asplenioides (L.) Dumort.

Frequent in wet habitats. All material collected has entire leaves. Dr. Conard informs the author that this condition is characteristic of Iowa material.

Porellaceae

Porella platyphylloidea (Schwein.) Lindb.

Neither abundant nor frequent. Found on tree trunks and rocks in moist woods. Also collected by Dr. Conard.

Frullaniaceae

Frullania eboracensis Gottsche

Frequent on tree trunks in moist woods. Also collected by Dr. Conard.

Frullania squarrosa (R. Bl. & N.) Dumort.

Collected by Dr. Conard at Palisades State Park. Conard (1942).

Blasiaceae

Blasia pusilla L.

Collected at Coggon pond by Dr. Conard. Conard (1942).

Marchantiaceae

Marchantia polymorpha L.

Frequent in moist shaded habitats. Also collected by Dr. Conard.

Preissia quadrata (Scop.) Nees

Collected by Dr. Conard at Palisades State Park. Conard (1942).

Conocephalum conicum (L.) Dumort.

More frequent than *Marchantia polymorpha* in similar habitats. Also collected by Dr. Conard.

Rebouliaceae

Reboulia hemisphaerica (L.) Raddi

Frequent on soil and in rock crevices in moist woods. Also collected by Dr. Conard.

Mannia rupestris (Nees) Frye & Clark

Reported by Shimek (1899) as *Grimaldia barbifrons* Besch. Shimek collection not seen by the present author.

Mannia fragrans (Balb.) Frye & Clark

Conard (1942).

Ricciaceae

Ricciocarpus natans (L.) Corda

Abundant on wet soil and in water at Chain Lakes. Previously reported by Conard (1940).

Riccia fluitans L.

Reported from Cedar Rapids by Shimek (loc. cit.). Also reported from Linn county by Conard (1942).

Anthocerotaceae

Anthoceros laevis L.

Collected by Dr. Conard on shore of pond south of Coggon. Conard (1942).

COE COLLEGE,
CEDAR RAPIDS, IOWA

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NOTES ON IOWA FLORA

W. A. ANDERSON

In her paper on *Violaceae of Iowa* Newbro (1936) included *Viola hirsutula* Brainerd. This is a small violet which grows characteristically in mixed angiosperm forests of the Appalachian region from Connecticut to Georgia. A number of Iowa specimens labeled *V. hirsutula* in the State University herbarium are *V. nephrophylla* Greene, a species which, according to Brainerd (1921), occurs from Quebec and New England westward to the Rocky Mountain region where it has a very wide range. This species was originally described from Colorado. In Iowa it seems most characteristic of our hillside bogs or fens. We have at the University of Iowa specimens from Cerro Gordo and Dickinson counties. It should be found in other counties from the northern part of the state. Apparently it has never been reported from Iowa. Our Iowa specimens have been compared with New England collections of *V. nephrophylla* which were kindly loaned by the Gray Herbarium.

Some other Iowa specimens which have been identified as *V. hirsutula* may be either *V. papilionacea* or *V. septentrionalis.* It is extremely doubtful if *V. hirsutula* occurs in the state.

In the summer of 1941 *Lapsana communis L.* was found in a weedy, heavily grazed woods near Crandall's Lodge, Dickinson County. Apparently this is the first report of this European weed in Iowa.

THE STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA

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NOTES ON IOWA PLANTS

George J. Goodman

The following plants either do not appear on Mr. Cratty's list (1933), in which case they are indicated by an asterisk, or they serve to augment the distributional data of certain of the species listed by him.

The specimens are in the herbarium of Iowa State College.

Gramineae (Grass family)

Buchloe dactyloides (Nutt.) Engelm. Buffalo grass.

In a yard at Ottumwa, Wapello Co., June 7, 1937. Coll. by Richard M. Hurd.

Full notes, kindly furnished by Mr. Hurd, state that this grass was found in several dense and very noticeable patches on a southern exposure of a lawn. The lawn is about 20 years old, and there has been no disturbance of the soil in that time. This is the most eastern station we know in the state.

**Chloris verticillata* Nutt. Windmill grass.

This collection also was made by Mr. Hurd in Ottumwa, June 28, 1938. His notes read "occurring rather sporadically in blue grass turf of yard. The soil has not been disturbed for 20 years."

Liliaceæ (Lily family)

Yucca glauca Nutt. Spanish bayonet, soapweed.

The list states "rare in the northwestern part in dry soil." Herbarium specimens from Iowa State College are from the following counties: Fremont, Mills, Monona (where it is especially abundant), and Plymouth. The species is common in Stone Park in Woodbury County.

Chenopodiaceæ (Goosefoot family)

**Chenopodium* (*Blitum*) *capitatum* (L.) Asch. Strawberry blite.

Allamakee County, June 23, 1939. Coll. by Fred Rily.

Saxifragaceæ (Saxifrage family)

****Ribes hudsonianum*** **Richards. Northern black currant.**

White Pine Hollow, Dubuque County, June 23, 1939. Coll. by D. R. Luhberts.

Minnesota is listed by the manuals as the southernmost locality for this species. Of the 41 sheets marked *R. hudsonianum* in the

herbarium of the New York Botanical Garden, 34 are from Canada and Alaska, 6 are from Minnesota, and one from Montana.

Rosaceæ (Rose family)

Crataegus Calpodendron (Ehrh.) Medic. Hawthorn.

"Frequent in the eastern part" according to the list. There are in the herbarium of Iowa State College two collections from Clay County by Dr. Ada Hayden, and one from Monona County and one from Mills County by the writer.

Leguminosæ (Pea family)

Astragalus lotiflorus Hook. Low Milk Vetch.

"Rare in the southwest section; Decatur and Fremont counties." The writer has collected this on the loess bluffs in Monona and Pottawattamie Counties, and Shimek (Shimek, 1897) reports it from Lyon County.

Cercis canadensis L. Redbud

Professor Fernald (Fernald, 1936) states that approximately half of the specimens in the Gray Herbarium have the leaves pubescent underneath.

Of the 25 leafy specimens from Iowa in the herbarium of Iowa State College all are hairy beneath. The amount of hair varies, but most of the specimens can be seen as hairy to the naked eye.

Of the 26 leafy specimens from out of Iowa in the herbarium of Iowa State College, only four are glabrous (f. *glabrata* Fernald). They are from the following states: La., Ark., Okla., and Texas. Of the 22 pubescent specimens, three are from Ill., one from Texas, one from Okla., and the remainder from states further eastward and southward.

Euphorbiaceæ (Spurge family)

**Acalypha ostryaefolia* Riddell.

Wabonsie State Park, Fremont Co., August, 1940. Collected by Louis C. Strohman. This locality is somewhat north of the range given in the manuals.

Aceraceæ (Maple family)

**Acer saccharum* Marsh. var. *Rugelii* Rehd.

Botany Camp. McGregor, Clayton County, June 19, 1940. Collected by H. C. Fink and M. B. Hatfield.

Rhamnaceæ (Buckthorn family)

The genus *Ceanothus* was omitted from Cratty's list through some slip. As a matter of record, it is here listed. Professor Shimek

(Shimek, 1923) mentions the reporting of typical *C. ovatus,* but inasmuch as the pubescent form is the only one I have seen from Iowa, the glabrate form is not listed.

**Ceanothus americanus* L. New Jersey Tea

Common

**Ceanothus ovatus* Desf. var. *pubescens* Wats.

Common

J. H. Soper (Soper, 1941) points out the reason for giving the author of the variety as Watson rather than Torrey & Gray. He also reduces the variety to a form, stating that the pubescent phase is found scattered throughout the range of the glabrate phase. Inasmuch as the Iowa material is dominantly, and perhaps exclusively, pubescent, a geographic segregation seems to exist and so the status of variety is thought to be more satisfactory.

Onagraceæ (Evening Primrose family)

**Gaura parviflora* Dougl. ex Hooker

All the material seen is referable to the "var. typica". Material in the Iowa State College herbarium is from the following counties: Fremont, Monona, Pottawattamie, Woodbury; also Iowa (along railroad embankment), Lee, and Story, where it is almost surely introduced.

Caprifoliaceæ (Honey suckle family)

The following genus also was accidentally omitted from Mr. Cratty's list.

**Sambucus canadensis* L. Elder.

**Sambucus canadesis* L. var. *submollis* Rehd. Pubescent Elder.

Davis County. Reported by Dr. Ada Hayden (Hayden, 1940).

**Sambucus pubens* Michx. Red-berried Elder.

S. racemosa of the manuals.

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IOWA STATE COLLEGE
AMES, IOWA

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THE GENUS *LYSIMACHIA* IN IOWA

George J. Goodman and P. J. Leyendecker

Many botanists, including students who have studied the Primulaceæ from a world viewpoint, consider *Lysimachia* and *Steironema* as one genus. *Lysimachia* is here considered in this broad sense.

Authentic material of five species and one variety from North Dakota, described by Greene and by Lunell, has not been seen, but any Iowa specimens examined that seemed to possibly agree with the original descriptions of the Dakota plants did not appear to be sufficiently distinct from the earlier described species, listed below, to warrant separating them.

Lysimachia (Tourn.) L. including *Steironema* Raf.

Key to the species:
Stems creeping, leaves suborbicular .... 2. *L. Nummularia*
Stems erect, leaves ovate or narrower.
  Plants covered with black dots.
    Inflorescence terminal racemes .... 1. *L. terrestris*
    Inflorescence short auxiliary racemes .... 3. *L. thyrsiflora*
  Plants not with black dots.
   Secondary leaf veins evident.
    Blades spreading-ciliate, ovate .... 4. *L. ciliata*
    Blades not spreading-ciliate, lanceolate .... 5 *L. hybrida*
  Only midveins evident, leaves linear .... 6. *L. quadriflora*

1. L. terrestris (L.) BSP.

Further characters for recognizing members of this species are the stems which *branch* and are covered with *elongated* spots.

Northwestern Iowa, from the following counties: Allamakee, Chickasaw, Fayette.

2. *L. Nummularia* L.

Native of Europe, and escaped from cultivation. All of our specimens are from the east half of the state, and very likely it does not occur in the west half, at least as an escape.

3. *L. thyrsiflora* L.

Stems unbranched, and the spots round.

Northern Iowa, from the following counties: Allamakee, Clay, Emmet, Fayette.

4. *L. ciliata* L.

Steironema ciliatum (L.) Raf.

Leaf blades near center of stem usually about twice longer than wide.

General in Iowa. Specimens seen from 32 counties.

5. *L. hybrida* Michx.

Steironema lanceolatum (Walt.) Gray and var. *hybridum* (Michx.) Gray.

Collections are scattered, but it is probably general in Iowa. We have it from the following counties: Allamakee, Clayton, Decatur, Dickinson, Emmet, Greene, Hamilton, Harrison, Jasper, Lee, Muscatine, Ringgold, Story, Warren.

For the interpretation of this species, see Fernald (1937).

6. *L. quadriflora* Sims
Steironema quadriflorum (Sims) Hitchc.
L. longifolia Pursh and of certain recent works.
Northern half of Iowa.

Occasional acceptance of *L. longifolia* Pursh as the correct name doubtless is based on the work of Pax and Knuth (1905). Here Sims' epithet is given as "quadrifolia." There is an earlier *L. quadrifolia,* of Linnaeus, so of course the Sims name appeared to be a homonym.

There is also a specimen at hand of *L. punctata* L., an introduced species collected in 1939 in Lynn County. Whether it is an escape or a cultivated plant is not clear.

The Iowa specimens examined are those in the herbarium of

Iowa State College.

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AMES, IOWA

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THE CUT-LEAVED NIGHTSHADE
(Solanum Triflorum Nutt.)

Nestor L. Stiles and Arthur L. Bakke

The cut-leaved nightshade, *Solanum triflorum* Nutt., was found in September 1941, in Rock Township, Cherokee County, Iowa. This nightshade was discovered growing in a pasture where there was a mixture of Clarion and Marshall soil types on the top of a bluff about twenty feet high where the soil was thin and gravely.

Solanum triflorum, cut-leaved nightshade, three flowered nightshade, or wild tomato, is a low spreading annual, reproducing by seed, slightly hairy, or nearly glabrous, leaves alternate, acute; flowers 1-3 inches; coralla white; berries greenish in color, about the size of a small cherry; seeds about 2 mm. long, obovate, flattened, minutely pitted, dull yellow to light brown.

According to Gates (1941), the plant was originally limited to native prairies of the Great Plains. With increased cultivation, the weed has extended and encroached on cultivated fields, pastures, gardens, pea fields and waste places (Muencher, 1935) and is common in the western half of Nebraska and Kansas. Over (1932) states that it is an annual, found on dry banks and prairie dog towns in South Dakota.

In the recent work of Robbins, Bellue and Ball (1941) the weed has been reported from four counties in California.

Chestnut and Wilcox (1901) state that the green berries which are half an inch or more in diameter are not attractive to the eye but have an agreeable odor and taste. Complaints of the poisoning of cattle by this plant have been sent in to the Department of Agriculture from Nebraska. Experiments with Guinea pigs have shown that the berries are poisonous. No case of human poisoning has been reported. Pammel (1911) states that he received complaints of poisoning by this plant from Nebraska and other Western states. The active constituent according to Pammel is attributed to solanin.

Thompson and Sifton (1922) have reported that the three-flowered, spreading or Prairie nightshade grows on the plains of Ontario and westward.

It is perhaps hazardous to even suggest means by which this plant has gotten so far from its course. The farm upon which the cut-leaved nightshade has apparently gotten a firm foothold has always carried sheep and the plant may have become introduced from that source. Apparently the plant is not new to the state as there is a specimen of *Solanum triflorum* Nutt. in the herbarium of Iowa State College collected by Professor Bruce Fink, August 6, 1894 at Fayette, Iowa.

IOWA AGRICULTURE EXPERIMENT STATION,
AMES, IOWA.
CHEROKEE, IOWA.

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THE EFFECT OF THE FREEZING TEMPERATURES IN DECEMBER 1941 AND JANUARY 1942 IN STORY, BOONE, AND POLK COUNTIES ON THE VIABILITY OF SOYBEANS OF THE 1941 HARVEST

John N. Martin

Owing to the urgency of increasing the soybean production in 1942, the condition of the soybeans held in storage for the 1942 seeding is a very important matter. The very unseasonable weather, both as to temperature and moisture, previous to and immediately after the harvesting of most of the soybeans, was a cause of no little concern about their viability.

Because of the excess in fall rains the beans were high in moisture, ranging in the main from 16 to 20 percent but reaching as high as 28 percent. With this high moisture content they were exposed to zero temperature on December 14. Following this date and previous to the holidays many of the beans were harvested. They had very little opportunity to lose much moisture before going into the bins where, during the latter part of December and in January they were exposed to an outside temperature reaching 20°F or more below zero.

Soybean samples were obtained from the bins of 12 different farmers who had harvested their beans with a high moisture content after the first freeze of December. The samples were obtained after the hard freeze in January and thus after the most severe cold of the winter. One sample was taken from the surface and the other from the interior of the pile.

The samples from 9 of the farmers germinated 80 to 92 percent when only good seedlings were counted as germinations. All 9 samples were yellow beans. One sample of yellow beans having a moisture content of 28 percent at harvest gave an average germination of 70 percent and two samples of black beans gave 50 to 60 percent germination.

Samples were taken also from plants still in the field after the January cold and viability tested. The germination of 12 samples representing as many different fields, ranged from 6 to 14 percent.

From the above data one can conclude that most of the yellow soybeans in the farmers' bins in central Iowa, at least, endured the unseasonable fall and January extreme cold with no considerable impairment of viability, whereas those beans remaining in the field were damaged beyond any use for seed.

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DISEASES OF CEREALS AND FLAX IN IOWA*

I. E. Melhus, D. R. Shepherd and Marie A. Corkle

Information relating to the prevalence and destructiveness of diseases of plants has been recorded in various journals and papers ever since the beginning of agriculture in Iowa. Most of these records are specific and valuable; some, however, especially for the early years, are so general as to have little value. In this paper an attempt has been made to summarize available records of the prevalence and destructiveness of the diseases of cereals and flax in Iowa and to interpret the early general reports on the basis of our present knowledge of plant pathology.

DISEASES OF CORN

Some diseases were observed in the Iowa corn crop as early as 1870 (Pammel and King, 1909), but previous to 1914 smut and rust were considered practically the only serious diseases of this crop. In 1914 (Pammel, Seal and King, 1915) a survey revealed that certain root, stalk and ear rots were responsible for widespread losses throughout the state. Yields in infected fields were reduced 10 to 15 bushels per acre, and a conservative estimate of the loss to Iowa farmers was $15,000,000.

As a result of the research work and surveys conducted during the past 20 years, it is now known that diseases are one of the important limiting factors in corn production in this state.

SMUT

Ustilago zeae (Beckm.) Unger

Smut was abundant on corn in Iowa in 1870 and no doubt was present before that time. Bessey (1884) wrote of corn smut, "Some years it is hardly noticeable while in others it is so abundant as to cause 15 percent loss." A few years before he had observed one field with a two-thirds loss. He reported that this disease was severe in 1887. Since 1870 this disease has been reported practically every year and has been general throughout the state. Since 1915 the annual loss has ranged from 1 to 9 percent.

Platz (1929) studied the occurrence of smut in 18 plots of Reid's Yellow Dent corn in different fields near Ames, Iowa, in 1923 and found that 7.9 percent of 17,255 plants examined were infected with smut. Similar investigations in 1927 revealed that of 3,974 plants examined, 15.7 percent were infected with smut. Archer (Plant Disease Rep. Sup., 1927, p.8) found that 13 percent of the 3,500 plants examined in scattered fields in the northern part of Iowa in 1927 were infected with smut, and 15 percent of 700 plants examined in Cass County were infected. Davis (1936) observed more than 9,000 corn plants near Ames during the period 1930-34 and found smut galls in more than 12 percent of them. These figures tend to indicate that the estimated annual losses from this disease may have been low.

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RUST
Puccinia sorghi Schw.

Rust on corn occurs generally through the state and has been observed to some degree practically every year since it was first recorded in 1870 (Pammel and King, 1909). The maximum loss (2 percent) was recorded in 1925 when 90 percent of the fields were affected. Normally the loss is only a trace.

In 1925 when the disease was relatively severe the alternate host, *Oxalis europea*, was generally infected, the fungus having been favored in its development by the warm, wet weather of June. The yearly distribution of the fungus throughout the state probably is dependent upon the distribution of the alternate host and favorable conditions for the development of the æcidial stage.

DIPLODIA DRY ROT
Diplodia zeae (Schw.) Lév.

Diplodia dry rot was reported first in Iowa by Holway (Gilman and Archer, 1929) in 1882. It was reported for the first time to the Iowa Plant Disease Survey in 1909, and that year it was observed in 16 counties and caused a 1.5-percent loss. It was reported next in 1915 from 28 localities. In 1921 the loss was 4 percent for the entire state. Durrell (1923) reported that of 650 ears collected in the north and east central part of the state in 1921, 11 percent were attacked by this fungus and were unfit for planting. Of 130 ears collected in the south central part of the state 7 percent were infected with Diplodia.

The condition in 1923 was even severer than in 1921. Fifteen percent of the seed planted was infected, which reduced the stand considerably. Later the rot of the stalk, ear and shank became prevalent, causing a loss of about 9 percent.

Since 1921 this disease has been responsible for severe damage each year. Losses have ranged from 1 to 10 percent. Losses for the past nine years were as follows: 1933, 4 percent; 1934, 9; 1935, 4; 1936, 10; 1937, 1938, and 1939, 1; 1940, 4; and 1941, 5 percent. In a study of the relative prevalence of the various fungi in carloads of corn that reached the terminal markets from Iowa, Hoppe and Holbert (Plant Disease Rep., 1936, p. 26) found 35 percent of the cultured kernels taken from damaged samples of the 1933 crop to be rotted by Diplodia. Eighteen percent were rotted by Diplodia in 1934. In 1935, 3.7 percent of the samples from 68 cars were affected by Diplodia (Plant Disease Rep., 1936, p. 312).

Porter (1925) in 1925 studied this disease in commercial fields throughout the state and analyzed the weather data for each locality for that year. He concluded that the amount of infection in a given growing season is dependent upon (1) abnormal August precipitation, (2) fairly high temperature, (3) the time when the corn plant loses weight, and (4) the presence of the spores of the pathogen.

Durrell (1923) found that during the years when Diplodia was most destructive the rainfall was normal or above at the end of the growing season. The losses since 1923 substantiate these findings. With normal temperatures and excessive moisture in August and September, this disease can be expected to damage the Iowa crop.

GIBBERELLA DRY ROT

Gibberella saubinetii (Mont.) Sacc.

Gibberella dry rot was first recorded by the Iowa Plant Disease Survey in 1909 when it caused a 2-percent loss. It was next recorded in 1914, and in 1915 it was widespread and serious throughout the state. Since that time it has been observed practically every year, the losses ranging from a trace to 6 percent.

Pammel, Seal and King (1915) worked with this disease in 1914 and 1915. They found perithecia of Gibberella associated with Fusarium but were unable to definitely connect Gibberella with the conidial stage. They referred to it merely as Fusarium. This may or may not have been this same fungus.

In recent years Gibberella has been considered along with Diplodia and Nigrospora as one of the troublesome dry rot fungi. It attacks the seed after it is planted in the spring, and later the stalk and ears.

Hoppe and Holbert (Plant Disease Rep., 1936, p. 26, 312) made platings from samples taken from carlots of Iowa corn that arrived at the terminal market in 1933-34-35. Gibberella was found in 3 percent of the samples from 14 cars in 1933, 4 percent from 135 cars in 1934 and 9.1 percent from 68 cars in 1935. These figures probably would be considerably higher if a sampling could be made of all corn on representative farms in view of the fact that the best corn no doubt is marketed.

NIGROSPORA DRY ROT

Nigrospora oryzae (B. and Br.) Petch

This dry rot was widespread in Iowa in 1923 (Durrell, 1925) and no doubt had been prevalent for several years prior to that time. That year it caused a loss of 9.1 percent for the state, and in a few fields, 50 to 60 percent of the ears were infected. Since 1923 this fungus has been found general throughout the state. The 9.1-percent loss in 1923, however, is the highest recorded.

In Iowa Nigrospora attacks the ears, stalks, shanks and husks. Under Iowa conditions Durrell (1925) found that this organism developed best when there was excessive moisture at the time the crop was maturing. The optimum temperature is 25°C. In years when this disease was destructive, August and September rainfall were normal or above. Reddy (1933) found that seed corn strains requiring high temperatures for germination were severely injured by this organism.

An indication (Plant Disease Rep., 1936, p. 313) of the prevalence of this fungus can be obtained from the isolations made from diseased samples that were taken from 68 carlots of 1935 corn at the terminal markets. Nigrospora was found in 13.9 percent of the plates.

BROWN SPOT

Physoderma zeae-maydis Shaw

Brown spot of corn was reported first in 1917 when it was found in three different localities. It has been recorded for only two years since that time, 1919 and 1928. In 1928 it was observed in one field in Boone County and in another in Mahaska County. In Mahaska County many stalks were broken over because of the severe infection. The disease does not occur generally throughout the state although it no doubt has been present more years than the records would indicate.

STEWART'S DISEASE

Bacterium stewartii (E. F. S.) Stevens

Stewart's disease no doubt has occurred in some locality in Iowa every year since its introduction although it has been recorded for only six different years. In 1933 it became severe, causing a 5-percent loss. The 5-percent loss reported for this disease in 1905 is referred to as the bacterial disease of Burrill, and this is not *Bacterium stewartii*.

This disease seemingly has been confined to restricted sections of the state and has not spread to any great extent. There apparently is no logical reason why this disease has not become severer. Stevens (Plant Disease Rep., 1934) studied this trouble in various sections of the United States with the idea of finding an explanation for the variation in destructiveness from one year to another. He concluded that there was no obvious relation between the incidence of disease and the total rainfall during any season or between the incidence of the disease and the temperature during spring, summer and fall. He did find, however, a possible correlation between the temperature indices for the winter months (sum of the mean temperature for December, January and February) and the incidence of the disease. He accepted as a working hypothesis the idea that this disease usually will be absent following a winter with an index below 90 and present in destructive amounts following a winter with an index above 100, with intermediate conditions following a winter between 90 and 100.

Following this line of thought for 1931 and 1933 when this disease caused considerable loss in field corn in Iowa, the index was found to be 91 for 1931 and 77 for 1933. Thus the winter temperature index might explain the condition in 1931 but not in 1933. In all probability this index would be different if it were figured for the counties where the disease occurred rather than for the state as a whole.

Purple Leaf Sheath Spot

Various Fungi and Bacteria

The purple sheath spot has been observed in Iowa since 1916, and it probably had been here some time before that. Durrell (1920), having studied this disease from 1916 to 1920, concluded that it was generally present in Iowa. During the latter part of the summer of 1918 he examined 9,620 stalks in representative fields and found 86 percent badly spotted with the purple leaf sheath spot. Although this disease can be found in Iowa to some extent each year, it normally does not cause any loss.

Other Diseases

Several other diseases have been observed occasionally on corn in Iowa, but they have not been found of economic importance.

Black bundle, caused by *Cephalosporium acremonium* Cda., was recorded by the Iowa Plant Disease Survey four different years, considerable damage occurring in 1929. Downy mildew, caused by *Sclerospora graminicola* (Sacc.) Schroet., was first recorded on corn in Iowa in 1925 by Melhus and Van Haltern (1925). That was the first instance where this organism was identified on corn in the United States. Holcus bacterial spot, caused by *Pseudomonas holci* Kendrick, has been known to occur in Iowa annually since 1916, but it never seems to become destructive.

DISEASES OF SWEET CORN

Sweet corn is an important canning crop in the state. The late varieties such as Country Gentleman have been largely used. Recently, however, certain of the new yellow hybrids are replacing the late varieties. Sweet corn, like dent corn, suffers from several diseases that may cause considerable damage. These are smut, rust, bacterial wilt, Diplodia dry rot, Nigrospora dry rot, Pythium root necrosis, etc.

SMUT

Ustilago zeae (Beckm.) Unger

Most varieties of sweet corn are more susceptible to smut than varieties of dent corn, which in part may be due to the fact that sweet corn is more likely to sucker than field corn. Corn smut has existed in the state for over forty years, but there are no detailed records of its destructiveness to sweet corn from year to year. It was officially recorded for the first time in the Iowa Plant Disease Survey in the year 1909. That year it was said to be common in the state and caused a loss of 1.5 percent. Smut injury varies from year to year and from one season to another and frequently causes losses ranging from 1 to 20 percent. Smut on sweet corn not only interferes with the growth and development of the plant but creates a problem by virtue of its presence on the kernels. Such infected ears have to be discarded or trimmed.

RUST

Puccinia sorghi Schw.

Rust on sweet corn is common throughout the state and causes some loss every year. It was first recorded in the Iowa Plant Disease Survey in 1905 when it was collected in 11 different counties. A 3-percent loss occurred in 1924 and 1925. The alternate host of this rust is *Oxalis europea,* which is generally distributed in the state but seldom heavily infected. The aecidial stage on Oxalis was studied by Smith (1926, Phytopath.).

BACTERIAL WILT

Bacterium stewartii (E. F. S.) Stevens

Previous to the past decade bacterial wilt was not a serious disease in Iowa. This in part may have been due to the practice of growing the late varieties of sweet corn, which in general are more resistant than the early varieties. During the past ten years there has been a tendency to discontinue the late varieties and to grow the early varieties. These seem to be more susceptible than the late ones. Severe losses were reported in the vicinity of Des Moines, Cedar Rapids, Oskaloosa, Fort Madison and Muscatine in 1932. In isolated cases from 40 to 50 percent of the plants in the field of early varieties were killed. In 1940 the estimated loss was less than 2 percent. The unusual prevalence and destructiveness of this disase from 1928 to 1932 cannot be explained alone by the increase in acreage of early varieties. It is possible that certain other factors were extant, but what these were is unknown. Recently very desirable resistant strains have come into existence that are higher yielding and more disease resistant than the old varieties. One of these, known as Ioana, has been developed and distributed by Haber at the Iowa Agricultural Experiment Station.

DIPLODIA DRY ROT

Diplodia zeae (Schw.) Lév.

Diplodia dry rot is most destructive to the roots and crowns of the plant although it may occur also on the ears and on the seed. In 1923, 15 percent of the seed was infected. It is not unusual to find 70 to 80 percent of the crowns discolored and infected with *D. zeae* in the fall after the crop is harvested. In August, 1927, Raleigh (1930) found Diplodia pycnidia on the stalk just above the crown of sweet corn plants. These plants were dead whereas apparently healthy plants had ears in the late milk stage. As a rule the ears sustain little injury, but occasionally there may be considerable ear infection. This was especially true in August, 1939. In some fields in Story and Hamilton Counties it was necessary to discard 20 to 30 percent of the ears in the field. In fact, it seemed for a while that the crop might not be worth picking. The ear rot developed at an astounding rate especially in the low lands north of Jewell. The later plantings were freer from rot than the early crop. Still further, rainfall ceased in August, and the infection seemed to be checked. Diplodia caused losses estimated as 7 percent for the entire state in 1940 and again in 1941.

NIGROSPORA DRY ROT

Nigrospora oryzae (B. and Br.) Petch

Nigrospora dry rot is of importance chiefly on seed. It was estimated in 1923 that 4 percent of the seed was injured by this disease. Losses in 1927, 1932 and 1933 were estimated as 4, 3 and 5 percent, respectively.

OTHER DISEASES

The scab organism, *Gibberella saubinetii* (Mont.) Sacc., and species of Fusarium and Pythium may cause considerable damage to the roots and crown, but so far no critical study has been made of the losses caused by these organisms.

DISEASES OF OATS

Oats have always been an important Iowa crop and since 1890 have ranked second in the acreage planted. Diseases on oats became so severe in the 1890's that there was question (Speer, 1890) as to whether Iowa could continue to grow oats as a profitable crop.

In 1915 the Iowa Agricultural Experiment Station undertook cooperative work with the United States Department of Agriculture on the disease resistance of oats. Dr. L. H. Pammel and Dr. William Diehl started the work in Iowa. In 1916 the senior author was assigned to this project. Doctors L. W. Durrell, R. S. Kirby, S. M. Dietz, H. C. Murphy and Mrs. Florence Willey Nichols are among those who have contributed notably to the disease resistance problem in Iowa.

The rusts and smuts probably were present in this crop from the time of the first planting, although the first record (Ia. Agr. Soc., 1858) of rust dates back only to 1858 and of smut, to 1884 (Bessey, 1884). In 1858 the oats crop failed throughout Iowa, and the majority of reports attributed the loss to rust.

The common diseases of oats in Iowa are crown rust, stem rust, smut, blast, scab, halo blight and Pythium root necrosis.

CROWN RUST

Puccinia coronata Corda

The early references to rust damage in the oat crop (Ia. Agr. Soc., 1858) probably referred to either or both crown and stem rust. Stem rust and crown rust were both known to be present in the state in 1882, but the records on prevalence previous to 1900 are too meager to make any definite statement relating to prevalence. It is thus problematical as to which of these diseases was more serious prior to 1900.

The first specific report of severe damage from crown rust came in 1907, at which time Pammel (I. S. C. Plant Disease Surv.) found the disease generally severe and estimated that it caused a loss of 50 percent of the crop. In 1908 it was reported from 34 counties and caused an estimated loss of 25 percent. Since that time crown rust has been reported every year except three, and it is logical to believe that crown rust was present to some degree even those years. The losses since 1908 have ranged from zero to 30 percent. The heaviest recent losses were those of 24 and 30 percent in 1938 and 1941, respectively. Crown rust occurs throughout the entire state wherever oats are grown.

The aecidial host (*Rhamnus spp.*) The common buckthorn was introduced into Iowa for hedge and ornamental purposes as early as 1854 (Ia. Agr. Soc., 1858, p. 265). In 1900 C. V. Stout (Pammel and Weems, 1900) of Grundy County reported that he had observed for a number of years that oats were very badly rusted in the vicinity of these hedges and had learned not to plant any oats in the immediate neighborhood.

Crown rust infection had been found on the buckthorn by Bessey (Arthur, 1924) in 1874. Pammel and Weems (1900) reported that the æcidia of crown rust frequently were found on the native buckthorn (*Rhamnus lanceolata*). Near Hinton, Iowa, in Plymouth County in 1920-21 (Melhus, Dietz and Willey, 1922) a serious epiphytotic of crown rust developed on a 120-acre farm completely surrounded by a buckthorn hedge. In 1921, 40 acres of oats surrounded on three sides by this hedge were entirely killed, and adjoining fields were seriously injured. Since 1930 many local epiphytotics of crown rust near buckthorn plantings have been observed. In some cases the oat crops have been complete failures. In one community in eastern Hamilton County, crown rust has become so severe near buckthorn that farmers have discontinued growing oats.

Dietz (1924) studied the effect of crown rust on yield of oats near Winthrop, Iowa, in Buchanan County in 1923. The initial infection was started by a hedge of *Rhamnus cathartica* adjoining an oat field. These oats were not cut, as many of them did not head. Oats planted in adjoining sections yielded 10 bushels per acre whereas the average yield in more remote sections of the same township was 50 bushels per acre.

The common buckthorn occurs generally throughout Iowa although most plantings for hedge and ornamental purposes are possibly in the east central counties. There are two native species, *Rhamnus lanceolata* and *R. alnifolia,* and two introduced species, *R. cathartica* and *R. frangula.* Only *R. cathartica* and *R. lanceolata* are susceptible to crown rust of oats under Iowa conditions.

Overwintering centers in Iowa. This phase of the epidemiology of crown rust in Iowa is not well understood. Melhus and Durrell (1919) were of the opinion that the rust might overwinter on volunteer grain in southern Iowa during mild winters, but they presented no positive evidence.

Overwintering centers in southern states. Dietz (1924) made a thorough study of the initial crown rust infection during the period 1916-24 and found that during each of these years the aecidial infection was observed on the *Rhamnus* spp. before it could be found on *Avena sativa.*

It is believed that during some years, especially years of serious epiphytotics such as 1941, crown rust spores were blown into Iowa en masse from infection centers in southern states and were directly responsible for the severe losses. During these epiphytotic years the rust seemed to appear simultaneously in all parts of the state and the degree of infection was correspondingly uniform in all regions. This indicated that there was a general shower of spores over the entire state and that during these years weather conditions were favorable for the subsequent development and spread.

Crown rust development is very dependent upon a combination of certain moisture and temperature conditions. An abundance of moisture and moderate temperatures in May favor the development of the æcidial stage on the Rhamnus. When these same conditions prevail in June the fungus makes a subsequent rapid development in the oats. During epiphytotic years the development and spread of the fungus have been influenced by weather conditions and also by the condition of the oat crop. Usually the crop is later than usual, stands are heavy and the growth rank. The fact that the crop is late has provided time for more generations of spores to develop on the host at a time when the oats are most susceptible to injury.

BLACK STEM RUST

Puccinia graminis Pers.

Pammel and King (1909) reported that black stem rust was present in Iowa in 1870. The first report (Arthur, 1924) of this disease that referred to a specific collection was made in 1882. There were reports of rust damage in oats in 1858, which may have referred to either or both rusts. Severe damage was reported in 1876, 1879, 1888, and 1893 (Ia. Agr. Soc., 1876, p. 25; 1879, p. 281, 282; 1888, p. 62; 1893, p. 57, 85).

Stem rust occurs generally throughout the state and occasionally causes serious losses. Since 1905 it has been present every year and was severest in 1926 when the loss was 10 percent of the crop. Losses for the past 10 years were as follows: 1932, 1 percent; 1933 and 1934, 0 to trace; 1935, 1 percent; 1936, trace; 1937 and 1938, 0.5 percent; and 1939, 1940, 1941, a trace.

It is difficult to explain the stem rust infection on oats some years as it is impossible each year to carefully study the local and general epiphytotics. There are three probable sources of stem rust in Iowa.

The aecidial host (*Common barberry*). Early in the history of Iowa agriculture the common barberry was found to be responsible for stem rust losses in the oat crop. In 1876 C. L. Watrous (Ia. Hort. Soc., 1876, p. 196) of Des Moines described spreads of stem rust to oats in Dallas County. Moore Briggs (Ia. Hort. Soc., 1879, p. 389) of Wyoming, Iowa, in 1879 described how oats growing near his barberry hedge had rusted every year since he planted the bushes. More recently similar cases have been observed. Melhus, Durrell and Kirby (1920) described spreads of stem rust to oats in Dubuque County in 1920. In 1926 spreads to oats were observed by Melhus and Smith (1927) in Fayette, Woodbury and Ringgold Counties. In 1934 a definite spread was observed in Fayette County.

The two other possible sources of stem rust of oats in Iowa are overwintering of uredospores and wind-blown inoculum from states south of Iowa. These have been discussed under "Wheat".

Normal Iowa June rainfall and temperatures slightly below normal are favorable for the development of the organism. These weather conditions also delay the maturity of the crop, and the host is thus subjected to an abundance of inoculum at a time when it is easily injured. The longer the time between the first infection and the ripening of the crop the severer will be the loss.

SMUT

Ustilago avenae (Pers.) Jens. and *U. levis* (K. and S.) Magn.

This disease was first specifically reported by Bessey (1884), who called it black smut and the organism *Ustilago segetum*. It was reported (Pammel, 1894) as abundant in 1894, and in 1901 Hume (1901) reported that it was severe each year. Bowman and Burnett (1905) took data from 80 fields where seed treatment tests had been run. The fields sown with formaldehyde-treated seed had 0.5 percent smut; those sown with nontreated seed had 5.9 percent smut.

In 1913 Hughes and Taff (1913) reported the results of a survey that they made of the oat smut situation in Iowa. Twelve thousand circular letters were sent to farmers who attended local short courses and to two-year students at Iowa State College in 1911-12. Each was asked to make one count in his own field and one in a neighbor's field. Counts were received for 3,668 fields, 3,356 from untreated fields and 312 from treated fields. In oats not treated there was 7.3 percent smut; in treated oats there was 1.9 percent smut. There were 11,037 acres treated and 1,218 acres not treated. The loss in some fields ran as high as 45 percent.

These statements merely emphasize the importance of this disease. Oat smut occurs in the state wherever oats are grown, and since 1912 the disease has taken a toll of each crop. Losses of 5 percent are common and occasionally 10 percent of the crop is destroyed. The epiphytotics in 1928, 1932 and 1941 were the severest that have occurred in recent years. Losses of 7 percent were recorded for each year. Losses of 5 percent occurred in 1921, 1924, 1925, 1926, 1933, 1937 and 1939.

Iowa weather conditions and oat smut development. The severest loss from smut has occurred in Iowa during those years when the moisture for April was low. Low soil moisture is not favorable for the growth of the oats and makes it more susceptible to attack by the fungus. As a rule the April temperatures have been above normal during years of severe smut infection, however, severe losses also have occurred during years of low April temperatures. There apparently is no relationship between smut losses and weather conditions during the other months of the growing season.

BLAST

Non-parasitic

Blast was first recorded by the Iowa Plant Disease Survey in 1905 (I. S. C. Plant Disease Surv.). That year 10 to 15 percent of the crop was affected. It was not recorded again until 1918 (Plant Disease Rep., 1918, p. 198) and that year it was generally prevalent. Blast occurs every year in varying amounts. No very accurate appraisal of its significance has been established.

Pythium Root Necrosis

Pythium debaryanum Hesse

Pythium root necrosis has recently attracted the attention of the pathologists at the Iowa Agricultural Experiment Station. Losses have been reported for the past four years as follows: 1938 and 1940, 12 percent; 1939, 6 percent; and 1941, 7 percent. The pathogen is generally distributed throughout the state and causes considerable damage during those years when April and May moisture is abundant and temperatures are low.

Other Diseases

Several other diseases have been observed periodically in the Iowa oat crop, but they have never been found to cause widespread losses.

Scab, caused by *Gibberella saubinetii* (Mont.) Sacc., was first reported by Pammel (Plant Disease Rep. Sup., 1920, p. 57) in 1904. Occasionally it is destructive in local areas. In 1919 scab became general, especially in Cherokee, Clay, and Kossuth Counties. Halo blight, caused by *Bacterium coronafaciens* Elliott, was first reported by the Plant Disease Survey in 1915. This disease is found generally throughout the state and occasionally causes serious losses. Anthracnose, caused by *Colletotrichum graminicola* (Ces.) Wils., occurs generally throughout the state, but the loss has never amounted to more than a trace of the crop. Foot rot, caused by *Helminthosporium* spp., was reported for the first time in 1917. It has been reported for only four years since then. One percent of the crop was damaged in 1933 and again in 1935. Stripe, caused by *Pseudomonas striafaciens* Elliott, has been reported for only two years. Ergot, caused by *Claviceps purpurea* (Fr.) Tul., was reported only in 1907 and 1908.

DISEASES OF WHEAT

The records of this crop for the period following 1858 contain many references to widespread losses from the rusts, smuts and blight. Even today in spite of the use of resistant varieties, seed treatment and sound cultural practices, much of the Iowa wheat crop is destroyed annually. The rusts, smuts and blights are still the important diseases although many others attack this crop.

Black Stem Rust

Puccinia graminis Pers.

Pammel and King (1909) reported that black stem rust was present in Iowa in 1870. This is the earliest specific report of this disease, but without doubt the black stem rust fungus was at least partially responsible for the widespread losses referred to as rust damage in 1858 (Ia. Agr. Soc., 1858).

It is problematical as to which rust was more destructive prior to 1900. If conditions were such as they are today, each of the rusts was severer in certain years. Pammel and Weems (1900) observed that orange leaf rust was more destructive in 1889 and in 1893 whereas in 1891 and 1892 black stem rust was more destructive. Carlton (1899) stated that stem rust year after year caused more damage to the wheat crop than did leaf rust. Burnett (1912) found that leaf rust was severer than stem rust, in tests run on 10 of the best of 40 varieties of wheat grown at the state college each year during the period 1906-1910.

In the first reports on agricultural conditions in Iowa rust is listed as the principal cause of reduced yields and small grain failures. It seems safe to assume that this disease was prevalent when small grains were first grown in the state.

The epiphytotic in 1858 is the earliest on record. That year practically every county reported (Ia. Agr. Soc., 1858) considerable loss from rust or wet weather and most of the wheat and oat crops were almost a complete failure. Typical of the reports for that year is that of Harrison County—"The wheat crop this year was small, probably one-third crop. Failure caused by rust," and of Jones County—"Wheat—This crop proved almost a total failure; thousands of acres not being touched, save by the 'torch.' The cause of the failure is attributed to the rust. Oats—a perfect failure—doubtful whether enough was raised, at any rate saved, for seed—cause of failure, the rust."

The losses from rust in 1858 were undoubtedly severer than usual for those early years. It is evident, however, that the crop was reduced materially in some parts of the state every year and that during years when there was an over-abundance of moisture in the spring drastic losses resulted. Two reports in 1859 (Ia. Agr. Soc., 1859) exemplify the condition that year: Davis County —"Wheat practically a failure—rust." Jefferson County—"Rust is the cause of reduced yields over a period of years."

Serious losses occurred again in 1865, 1866, 1869, 1872 and 1876. In 1876 the condition in the early summer was somewhat similar to 1858. There was an abundance of rainfall, and temperatures were high during the critical period for the small grain crops. County reports (Ia. Agr. Soc., 1876) for that year again point to rust as the critical factor in production. Typical of these are Black Hawk—"Rust injured wheat," Cherokee—"Rust almost destroyed crop," Decatur—"Spring wheat entire failure because of rust," Jackson—"Rust injured wheat," Jones—reference was made to rust and blight injury, Kossuth—"Rust seriously injured the crop," Allamakee—"The earlier part of the season was wet and this followed by hot weather produced a blight that ruined many wheat fields and seriously affected all growing grains," Warren—"Wheat badly damaged by rust and wet weather. Not more than one fourth."

A similar condition existed in 1898 when many counties reported partial to complete failure from rust, blight and wet weather, the latter two no doubt being synonyms for rust.

Serious losses were reported in many parts of the state in 1880, 1882, 1888, 1889, 1890, 1893, and 1897. Serious losses were reported again in 1898 with many counties reporting partial to complete failure from rust, blight and wet weather.

Since 1900 the records of plant disease losses have been more specific, and on the basis of these figures it is obvious that black stem rust has been prevalent in the state every year. The most severe loss, 19 percent, was suffered in 1937. It is known that there were severe epiphytotics in Iowa in 1904 and 1916: however, no actual loss figure was recorded for those years. It is believed that the rduction in yield was even greater those years than it was in 1937.

In Iowa there have been three possible sources of rust: (1) the æcidial host, the common barberry, (2) local overwintering centers and (3) overwintering centers in states south of Iowa.

The common barberry was first introduced into Iowa about 1851 and has been an important potential source of rust each year since that time. It was not long after the introduction of the barberry into Iowa that people began to suspect it as the source of early stem rust inoculum. The evidence against the barberry soon became conclusive, and in many communities it lost its popularity as a shrub for hedge and ornamental plantings. In the communities where it was planted it was definitely found to be a source of stem rust. Typical of the early reports is one made by C. L. Watrous (Ia. Hort. Soc., 1876, p. 146) of Des Moines in 1876: "This society has sometimes discussed the barberry as a hedge plant. I have to report one experience with it. In 1874 A. Nighswander of Dallas County planted 100 yards or so of barberry hedge, using two year old plants. The same season oats growing close by rusted badly, while the balance of the field escaped. In 1875 wheat growing near it was killed, the injury shading off one-half to three-fourths of a mile south and west. North and east was prairie. Wheat generally suffered from rust but that near the hedge to a far greater extent. In 1876, oats near it was utterly killed and left on the ground the injury gradually shading off as before."

There were many similar instances of early rust spreads traceable to barberry. In 1879 Moore Briggs (Ia. Hort. Soc., 1879, p. 348) of Wyoming, Iowa, condemned the barberry after having observed spreads to wheat and oats for six successive years. In 1881 W. L. Brockman (Ia. Hort. Soc., 1881, p. 315) reported: "I sold plants of the barberry to a farmer for a garden hedge. His wheat has been blighted by a rust resembling that on the barberry. As this complaint has often been made, I think it will be well to stop its propagation in the nurseries."

Melhus, Durrell and Kirby (1920) in 1918 recorded 16 local epiphytotics of stem rust traceable to the barberry. Muncie (1922) reported spreads observed in 1923. In 1925 Smith (1926, U. S. D. A.) listed 10 cases where rust was found to have spread from barberries, and in 1928 Rohrbaugh (1928) recorded the spreads from barberries observed that year.

Evidence based upon experimental work and observations of Bolley (1891), Lambert (1929) and Smith (1926, U. S. D. A.) indicates that local overwintering centers are not significant as a source of early spring infection in Iowa. In fact the evidence based on observations made over a period of years indicates that black stem rust does not overwinter in Iowa.

The rust overwintering in Mexico and Texas spreads north progressively to grain fields in Oklahoma and from there into Kansas, Missouri, and other states to the north some years when conditions of wind, temperature and moisture are favorable. Since 1930 slides have been exposed each year in an effort to determine to what extent rust is carried into Iowa by the wind from southern states. These exposures have shown conclusively that rust does move into Iowa and that the amount of inoculum varies with the amount of rust in the southern states as well as with the time of and the velocity of the prevailing south winds.

Years when spores are blown in from the south a general sprinkling of rust appears almost simultaneously in all parts of the state about the middle of June. This general infection is easily distinguished from the early local spreads that have originated from infected barberries.

It has been observed that serious losses result from the wind blown inoculum only during those years when there is an abundance of rust in the southern states, when winds from the south prevail for several days during the growing season, when Iowa crops are later than usual and when environmental conditions favor the infection and spread of the fungus.

The Elimination of Spring Wheat as an Iowa Crop

Diseases have had a profound effect on wheat culture in Iowa and obviously have been largely responsible for the almost complete elimination of spring wheat as an Iowa crop.

Prior to 1860 there was a larger acreage of winter wheat than spring wheat in Iowa. The varieties, however, were not hardy, consequently spring wheat became the predominant crop. In the reports to the Iowa Agricultural Society, 42 counties reported winter wheat in 1857, only three counties reported winter wheat in 1870, and in 1872 there was so little that the secretary of the society did not differentiate between spring and winter wheat.

After 1880 there was a gradual reduction in all wheat and farmers were gradually changing back to the fall sown crop. Spring wheat continued to go out of the picture, and during the 50-year period 1875 to 1925 the acreage was reduced from more than 3,000,000 acres to 29,000, about a 90-percent reduction.

Iowa farmers did not discontinue spring wheat production because they wanted to. There had always been a real need for a profitable spring crop to fit into the rotation with corn. Oats have been used because spring wheat has been uncertain and unprofitable. If it were not for the annual losses in spring wheat from plant diseases, especially black stem rust, Iowa no doubt would have continued growing large acreages of this crop instead of oats, which over a period of years have not been profitable.

Probably no one factor or combination of factors has been more responsible for the elimination of spring wheat in Iowa than has black stem rust. It is true that previous to 1900 the records refer to the cause as rust, blight and wet weather; however, there are many indications that the three terms were synonyms and that the rust was the most damaging. The fact that the blight and rust invariably attacked the crop just before harvest is circumstantial evidence that the rust was black stem rust. The extent of the damage year after year is also an indication that stem rust was the prevalent disease.

Orange Leaf Rust

Puccinia rubigo-vera (DC.) Wint. var. *tritici* (Erik. and Henn.) Carl.

This rust was first reported (Bessey, 1884) specifically in 1884 and that year was observed to be more prevalent than was black stem rust. Bessey wrote of this disease this year: "This is the gray colored rust of wheat. It is much more harmful than the common rust (*Puccinia graminis*) and every year causes a great loss in the wheat crop." The records of rust prior to 1884 do not distinguish between the two common wheat rusts; consequently we can only assume that both rusts were present.

Orange leaf rust occurs throughout the entire state where wheat is grown. Pammel and Weems (1900) found the disease very destructive in 1889 and 1893. It was very severe in 1927, 1935, and 1938, causing losses of 15, 20 and 28 percent in those respective years.

During the early years of Iowa agriculture the losses from this disease obviously were underestimated. Orange leaf rust attacks the crop early in the season, and often many lower leaves are completely destroyed. The upper leaves with fewer pustules persist and remain green, the heads develop normally and the plants remain upright so that the loss of the lower leaves is not always noticeable. Other diseases become prevalent later, cause discoloration of the stems and leaves and cause lodging just prior to harvest. These other diseases have received the blame for the damage done earlier in the growing season by the leaf rust. The reduction of the leaf surface by this leaf parasite obviously has always been responsible for considerable damage.

The fact that orange leaf rust has not been considered serious accounts for the fact that most of the common varieties of spring and winter wheat grown in Iowa have been developed without considering resistance to the fungus. Marquis, Ceres, Komar and Thatcher are completely susceptible. Of the winter wheats, Iowin and Iobred have some resistance, but Turkey Red is very susceptible.

Leaf rust overwinters in Iowa and appears in the fields early each year. It becomes most destructive during years when the growing season is prolonged by a cool, dry spring and when there is an abundance of moisture and high temperatures early in summer. The use of semi-resistant varieties of winter wheat such as Iowin and Iobred is the only protective measure.

SCAB

Gibberella saubinetii (Mont.) Sacc.

The earliest report of scab was made in 1865 (Ia. Agr. Soc., 1865, p. 15) when it was reported to have greatly damaged the crop in many locations. It was reported again in 1866, 1869, and 1878 (Ia. Agr. Soc., 1866, p. 353; 1869, p. 276; 1878, p. 354). Pammel (1892) reported this disease specifically for the first time in 1892 when it did serious damage.

The plant disease survey reported general scab epiphytotics in Iowa in 1918, 1919, 1924, 1931 and 1938 with heavy losses in 1918 and losses of 22, 5, 15 and 5 percent of the other four years, respectively. Scab was also severe in some fields in 1935 although the loss for the state was only 1½ percent.

This fungus in Iowa is favored by abundant June rainfall and relatively low June temperatures. Usually the losses have been general throughout the state (Plant Disease Rep. Sup., 1919, p. 133; 1920, p. 31; 1924, p. 264). Both the spring and winter wheats are damaged by this disease.

Scab presents a difficult problem in that the causal organism also causes a disease of corn. Inoculum is readily available on the old corn stalks and refuse in the field, and thus it is hazardous to follow corn with wheat.

COVERED SMUT (BUNT)

Tilletia levis Kühn and *T. tritici* (Bjerk.) Wint.

Pammel and King (1909) reported that bunt, or covered smut, was present in Iowa during the period 1871-1877. In 1863 Clark (Ia. Agr. Soc., 1864, p. 207) of Pottawattamie County described a procedure that he followed in treating his seed wheat with blue vitriol to control smut. If he obtained control by this method, he must have been dealing with covered smut. Other farmers (Ia. Agr. Soc., 1878, p. 353) referred to smut injury prior to 1871; however, it is not known to which of the two wheat smuts they referred. Referring to bunt in 1900 Pammel said:

"*Tilletia tritici* is not common in Iowa but it has been found several times since 1891 in the field and also from the screenings from local mills. The damage is very small in Iowa."

Since 1900 bunt has been observed practically every year. Usually the loss has been spotted, some fields having considerable loss and others having none. In 1918 Melhus (Plant Disease Rep., 1918, p. 116) said: "*Tilletia tritici*, a trace. It is general and nominal in quantity except in spots. Usually there is only a trace but cases have been found where 25 percent disease occurs." In 1926 Elmer (Gilman and Porter, 1927) made a survey of the bunt conditions in Iowa and found that although the yield was reduced over the state by only 0.5 percent, in some fields severe losses occurred. In one field in Plymouth County 40 percent of the heads were infected, and frequently 5 to 10 percent of the heads in a field were destroyed. Reports (Plant Disease Rep., 1932, p. 62) in 1931 from 21 farmers comprising 475 acres where seed wheat was not treated listed the average loss caused by bunt as 1.16 percent. This disease occurs wherever wheat is grown in the state. Since infection originates from spores that are carried to the soil on the seed, effective control can be obtained by the use of chemical seed disinfectants. Although *T. tritici* has been observed often in Iowa, *T. levis* is the common species.

LOOSE SMUT

Ustilago tritici (Pers.) Jens.

Bessey (1884) reported this organism first in 1884 under the name *Ustilago segetum*. In one field 60 percent of the heads were affected. It is very likely that some of the reports of smut made by growers in 1864 and 1866 (Ia. Agr. Soc., 1876, p. 10; 1866, p. 353) were of this disease. Pammel and Weems (1900) wrote: "Loose smut (*Ustilago tritici*) occurs wherever wheat is grown. We have observed it abundantly in many portions of Iowa." They considered that the annual loss was not far from 0.5 percent.

Since 1900 this disease has been reported in all but three years, and it probably was present during these years. The loss of 4 percent in 1916 is the highest; losses of 1 percent have been common. Since 1930 the writer has observed this disease in practically every wheat field inspected, but losses have been only a trace to 1 percent.

BLACK CHAFF

Pseudomonas translucens **var. *undulosum*** **S., J. and R.**

Black chaff was found for the first time in Iowa in 1917 by Erwin F. Smith (Plant Disease Rep., 1917, p. 40). In 1918 (Plant Disease Rep., 1918, p. 99) it was found in samples from Plymouth, Woodbury, Harrison, Pottawattamie, Mills, Adams, Montgomery, Warren, and Story Counties. In 1919 (Plant Disease Rep., 1919, p. 85) this disease was reported as severe and common. It was found in 104 out of 208 fields inspected and was most common on winter varieties. Since 1919 black chaff has been relatively unimportant, the losses in most years amounting to only a trace. It is probable that during this period the disease has been overlooked and that losses have been severer than the records show.

OTHER DISEASES

Disases of less importance that have been observed on wheat in Iowa are leaf spot caused by *Septoria tritici* Desm., glume blotch caused by *Septoria nodorum* Berk., powdery mildew caused by *Erysiphe graminis* DC., anthracnose caused by *Cladosporium graminum* Cda. and ergot caused by *Claviceps purpurea* (Fr.) Tul. The yearly reports for these diseases are incomplete largely because the losses are relatively unimportant.

It has been observed that *Helminthosporium gramineum* (R.) Erik., a species of Fusarium and *Pythium debaryanum* Hesse cause some seedling blight and root necrosis each year.

DISEASES OF BARLEY

Plant diseases annually decrease the yield of barley. This crop is very susceptible to stem rust, scab, stripe, spot diseases, Helminthosporium blight, root rots, smut and bacterial blight. Barley probably suffers more injury from diseases than any other cereal crop grown in the state.

In field experiments testing the response of barley varieties to disease in Iowa, Burnett and Reddy (1937) found several instances from 1928 to 1935 when diseases became the critical factor in the production of the crop. In 1928 and 1935 scab was severe. In 1932 the destructive diseases were Helminthosporium root rot and bacterial blight.

BLACK STEM RUST

Puccinia graminis Pers.

Stem rust occurs generally throughout the state and causes greater losses than any other disease of barley. The first specific report of this disease on barley was made by Bessey (1884) in 1884. Since 1918 stem rust has been reported each year, with losses varying from a trace to 17 percent. The losses sustained in 1920, 1935 and 1937 were 17, 10 and 15 percent, respectively.

BARLEY SCAB

Gibberella saubinetii (Mont.) Sacc.

The disease not only reduces the yield but makes the grain unfit for feed and for malting purposes. Scab was first reported on barley in 1909 (Plant Disease Rep. Sup., 1920, p. 48). It was observed to be generally severe in 1919, causing a loss of 5 percent. In 1928, 1932 and 1935 scab caused losses of 8, 6 and 15 percent, respectively.

In a survey following the 1935 epiphytotic (Plant Disease Rep., 1936, p. 11) *Gibberella saubinetii* was found to constitute 84 percent of the organisms isolated from infected seed from the southeast to south central section, and 80 percent of the organisms isolated from seed from the north central to northwest section of Iowa.

BARLEY STRIPE

Helminthosporium gramineum (R.) Erik.

Stripe in barley was reported to have been present in Iowa in 1892 by Pammel and King (1909). By 1900 it was considered (Pammel and Weems, 1900) as one of the most destructive diseases of the barley crop. Since then it has been prevalent each year, frequently causing losses of 5 percent. Fields have been observed often (Plant Disease Rep., 1929, p. 106) where 30 to 35 percent of the plants were affected.

Archer (Plant Disease Rep. Sup., 1927, p. 6) observed a large number of barley fields in 1927 and made this comment:

"The greater number of the fields in the state had some stripe but it was very slight and occurred only on the lower leaves. It was reported, however, to be quite destructive in a number of localities in scattered fields."

SPOT BLOTCH, BLIGHT, ROOT ROT

Helminthosporium sativum P., K. and B.

Helminthosporium sativum causes spot blotch, blight and root rot in the barley crop. In 1909 when it was reported for the first time it was found in nine counties and in some fields caused a 50-percent loss. There were reports of discoloration, wet weather damage and blight in 1865, 1882 and 1891 (Ia. Agr. Soc. 1867, p. 423; 1882, p. 23; 1891, p. 371) which may have been caused by this organism. Since 1909 this disease has been observed practically every year and occasionally has caused severe local losses.

This organism is found as widespread in the state as in the scab organism. It appears to be more prevalent and destructive on the heads at periods of high temperatures and fairly low humidity.

Burnett and Reddy (1937) considered *H. sativum* to be one of the most destructive organisms occurring in Iowa. They found root rot caused by this organism to be one of the critical factors in barley production in the varietal test plots in 1932. The disease was unusually severe in 1931 and 1933 (Porter and Layton, 1936). The greatest recent loss was 6 percent in 1937.

LOOSE SMUT

Ustilago nuda (Jens.) K. and S.

This disease was reported by Bessey (1884) in 1884. In 1866 there was a report.(Ia. Agr. Soc. 1866, p. 381) of smut on barley in Jefferson County, which may have been either the loose or covered smut. Since 1892 loose smut has been observed practically every year, and although the loss has not been severe it has been fairly consistent year after year. This disease occurs generally throughout the state.

Burnett and Reddy (1937) consider loose smut as one of the important barley diseases, especially since the smooth-awned varieties have been introduced. The varieties Colsess, Glabron and Spartan are very susceptible, but Manchuria and O. A. C. 21 are very resistant under Iowa conditions.

COVERED SMUT

Ustilago hordei (Pers.) K. and S.

Covered smut on barley in Iowa was first reported by Pammel (1894) in 1894. He indicated at that time that it was more common than loose smut. This disease has been observed practically every year since the first report, the annual losses ranging from a trace to 3 percent. It occurs generally throughout the state.

BACTERIAL BLIGHT

Pseudomonas translucens J., J. and R.

This disease has been considered of importance as a barley disease in Iowa only in recent years. It was recorded first by the Plant Disease Survey in 1927. In 1932 it caused 2 percent loss and was responsible for 8 percent damage in 1937. In the varietal tests in 1932 (Burnett and Reddy, 1937) bacterial blight was one of the critical factors in production. All the important commercial varieties grown in Iowa are very susceptible to this disease.

SCALD

Rhynchosporium secalis (Oud.) Davis

Scald was responsible for a slight loss to this crop in 1925 (Plant Disease Rep., Sup. 1926, p. 337). No loss has been recorded prior to that time, and since then the disease has not been observed in Iowa.

EUROPEAN NET BLOTCH

Helminthosporium teres Sacc.

This disease was reported consistently in Iowa during the period 1921 to 1929 and some years caused a 5-percent loss. It appears, however, that the loss was overestimated during some of the years.

ROOT ROT

Pythium graminicola Subr.

This organism was first found on barley in Iowa in 1936 (Ho, Meredith and Melhus, 1941). That year barley stands were unusually thin and the plants yellow and stunted in many fields in central Iowa. Pythium root rot has occurred each year since to some extent and caused considerable injury in 1936 and 1938.

In soil heavily infested with *P. graminicola* the seeds may be attacked and become soft, water-soaked and rotted, thus greatly reducing the stand. Necrotic lesions may be found on the roots of infected seedlings one week old, followed by yellowing of the leaves two or three weeks later.

OTHER DISEASES

Less destructive diseases of barley are powdery mildew, leaf rust, anthracnose and Septoria leaf spot. The records of these diseases are incomplete largely because they are of minor importance.

DISEASES OF RYE

Rye is the least important of our cereal crops in this state. It is grown only on the light sandy soils. The two diseases common on rye are ergot and stem rust.

ERGOT

Claviceps purpurea (Fr.) Tul.

Ergot was common in the state from 1871 to 1877. It occurs annually but seldom becomes destructive. Ergotism in livestock is said to have been common in the eighties.

STEM RUST

Puccinia graminis Pers.

This disease occurs every year but rarely causes serious injury to rye. This in large measure is probably because the crop matures the latter part of June, which is too early for a rust epiphytotic to develop. It has been shown, however, that where rye grows adjoining common barberry, severe losses to the crop may result. In 1938 near Sharpsburg in Taylor County, stem rust spread early from infected barberries to nearby rye fields. Fifty acres of this crop grown on two different farms were completely destroyed. This was a very interesting observation in the light of what is known of stem rust injury in Europe, where rye is a much more important crop than in this country and where stem rust has frequently caused very serious losses to the crop.

OTHER DISEASES

The diseases of less importance that have been observed on the rye crop in Iowa are as follows: Smut, caused by *Urocystis occulta* (Wallr.) Rabenh.; powdery mildew, caused by *Erysiphe graminis* DC.; scab, caused by *Gibberella saubinetii* (Mont.) Sacc.; leaf rust, caused by *Puccinia rubigo-vera* (DC.) Wint. var. *secalis* (Erik. and Henn.) Carl.; and leaf spot, caused by *Septoria secalis* Prill. and Del.

DISEASES OF TIMOTHY

Although timothy is grown generally throughout the state, there have been only a few reports of the occurrence of diseases on this crop, and these were not considered serious. The two best known diseases of timothy are stem rust and smut. These occur generally over the state but seldom become destructive.

STEM RUST

Puccinia graminis Pers.

Stem rust was first observed on timothy in Iowa by Pammel and King in 1910. Only occasionally has it been prevalent and destructive. Infection apparently takes place early in the spring because the teleutospore stage is fully developed by July 1.

SMUT

Ustilago striaeformis (West.) Niessl.

Smut on timothy is systemic and perennial. It was first observed in the state in 1889 and has occurred annually since 1916. Smut occurs generally wherever timothy is grown but seldom becomes prevalent and destructive.

SPOT DISEASES

Scolecotrichum graminis Fckl., *Sporotrichum poae* Pk., and an Unnamed Bacterium.

The spot diseases caused by *Scolecotrichum* and *Sporotrichum* occur on the foliage and cause premature dying of the leaves. It is believed that in some seasons these organisms result in considerable injury. The bacterium that causes the spot disease on this crop has not been named, and little or no information is at hand regarding the causal organism. The symptoms are water logging of the parenchyma between the veins, followed by the deposition of a thin layer of exudate. This exudate is highly charged with bacterium. Later the affected spots turn brown.

DISEASES OF SORGHUM

Diseases have been observed on sorghum since early in the nineties of the last century. Sorghum is only a minor crop in Iowa.

BACTERIAL STRIPE

Pseudomonas andropogoni E. F. S.

Bacterial stripe is the only bacterial disease that causes important losses, and these are usually local in scope. This disease was observed (Pammel and King, 1909) in Iowa in 1890. In 1905 the disease was found in scattered localities and 1 percent of the crop was injured. Occasionally since 1905 the disease has been serious, and in 1916 (I. S. C. Plant Disease Surv.) 4 percent of the crop was injured. In 1924 (I. S. C. Plant Disease Surv.) the disease was severe in northwest Iowa and caused a 2-percent loss. No observations have been recorded since 1924, although it is probable that the disease has been present in some parts of the state.

BACTERIAL LEAF SPOT

Pseudomonas holci Kendrick

Bacterial leaf spot has occurred annually since it was first described by Kendrick (1926). He determined by field observations and greenhouse inoculations that the following were hosts: 22 varieties of *Sorghum vulgare* (sorghum), *S. vulgare* var. *technicum* (broomcorn), *S. vulgare* var. *sudanense* (sudan grass), *S. halepensis* (Johnson grass), *Pennisetum glaucum* (pearl millet); 20 varieties of *Zea mays*, 11 of which were dent corn, 2 flint corn, 6 sweet corn and 1 pop corn, and *Setaria lutescens* (foxtail). The following plants could not be infected in repeated greenhouse inoculations: *Triticum aestivum, Avena sativa, Bromus inermis, Arrhenatherum elatius, Dactylis glomerata, Lolium perenne, Phalaris* sp., *Agrostis alba, Phleum pratense, Festuca eliator* and the Japanese, Siberian, common, Hungarian and broomcorn varieties of *Setaria lutescens*.

The disease on the species of Sorghum is characterized by light-centered, red-bordered, round, elliptical lesions on the leaves. Very small lesions are red throughout. Often the spots are so numerous as to cause the death of the entire leaf. On *Sorghum vulgare* variety *Shallu,* the lesions have a dark brown instead of a red border, and on *Pennisetum glaucum* and *Setaria lutescens* the spots are a dark brown throughout with a narrow light green halo.

HEAD SMUT

Sorosporium reilanum (Kühn) McAlp.

This fungus was collected (Hume, 1901) first in 1894. It occurs regularly every year in all parts of the state, frequently becoming very destructive. In 1940, 48 percent of the heads were smutted in a field of sorghum at Cherokee.

Another smut, kernel smut, caused by *Sphacelotheca sorghi* (Lk.) Clint., occurs on sorghum, but it is relatively unimportant in Iowa.

DISEASES OF FLAX

In Iowa as in practically all other states, flax remained an important crop only as long as new land was available for its culture. In the early period of Iowa agriculture it was generally thought that flax depleted the soil to such an extent that subsequent flax crops were either very mediocre or complete failures. It is estimated that 322,000 acres were sown to this crop in this state in 1885, and by 1922 this number had been reduced to less than 6,000. In recent years, since disease-resistant varieties of flax have been developed, Iowa farmers are again growing it. In 1932 more than 23,000 acres were harvested, and in 1941, 234,000 acres were harvested in this state.

FLAX WILT

Fusarium lini Bolley

The cause of the flax wilt disease was discovered in 1901 by Bolley (1901) who showed that the presence of a species of Fusarium in the soil was responsible for flax failures. In recent years wilt-resistant varieties have been developed, and flax growing is no longer restricted to new land. In 1931, 1932, 1933 and again in 1935, after cropping to corn in 1934, a wilt-resistant variety of flax was successfully grown on the same piece of land at Kanawha, which demonstrates the great difference between the new resistant varieties and those grown when flax was considered only a "new land" crop. Each year it was possible to find some wilt, but the injury was never severe. That the soil was infested with the wilt organism was shown in 1933 when all the plants of a susceptible variety that were planted in a strip across the same field were killed by the wilt pathogen. This prevalence of *F. lini* in the soil is interesting because of the fact that only wilt-resistant varieties had been grown during previous years.

Wilt was reported first in Iowa in 1906, but from then until 1921 no records of its occurrence were kept. Since 1921 it has been observed and recorded only during occasional years, the greatest loss, 5 percent, coming in 1927. Commenting on the disease and crop that year Archer (Plant Disease Rep. Sup., 1927, p. 22) said:

"Twenty years ago flax production was an important industry in the state but the severity of losses from wilt brought about general discouragement so that the acreage shrank to practically nothing. In recent years, however, the universal use of wilt resistant varieties has reduced wilt losses and the acreage is increasing."

Flax wilt occurs every year where the resistant varieties are used, but in no case does the wilt organism seriously injure stand or yield.

RUST

Melampsora lini (Pers.) Lév.

Rust of flax has been recorded only twice by the Plant Disease Survey, although it is known to occur to some extent practically every year. The restricted acreage probably has kept this disease under control, but the disease may increase as the acreage increases. In 1941 it was said to be prevalent in northwestern Iowa.

SEED DECAY, SEEDLING DAMPING-OFF AND ROOT NECROSIS

Pythium debaryanum Hesse and *Rhizoctonia solani* Kühn

Flax stands are reduced considerably each year in Iowa through seed decay, damping-off and root necrosis. Buchholtz (1935) showed that *Pythium debaryanum* caused seed decay and seedling injury of flax. Both *P. debaryanum* and *Rhizoctonia solani* occur in most Iowa soils, but the former organism is the more destructive. Losses caused by *P. debaryanum* were estimated as 20 percent in 1935 and 1936 and as 10 percent in 1937, 1938 and 1939.

It has been found that seed treatment will increase the yields of early sown flax in all probability by controlling these soil-borne organisms. In 1935, 1936 and 1937 treatment of seed of Redwing and Bison increased field stands 68.0, 20.7 and 9.6 percent, respectively.

PASMO DISEASE

Phlyctaena linicola Speg.

Pasmo, has been recorded only once, in 1932, by the Plant Disease Survey. It was estimated to have damaged 1 percent of the crop that year.

BOTANY AND PLANT PATHOLOGY SECTION
IOWA AGRICULTURAL EXPERIMENT STATION
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MME. CAROLINE TESTOUT*

The Grand Dame of the Roses.

CLARK D. PARIS AND T. J. MANEY

In all breeding work one finds that certain individuals are outstanding in the production of superior progeny. In animal breeding these individuals form the basis for pedigreed stock. An intensive study on the parentage of rose varieties has revealed that certain roses also have produced more named offspring than others. To obtain this information, it was necessary to make a search through the world's most important literature on the rose. This study resulted in the compilation of an index of about 5,000 rose varieties on which parentage data had been recorded.

One of the most outstanding parents among the Hybrid Teas has been Mme. Caroline Testout, the well-known satiny rose-colored rose introduced in 1890 by Monsieur J. Pernet-Ducher. The late J. H. Nicholas in his *A Rose Odyssey* related a very interesting anecdote regarding the naming of this rose. It seems that Mme. Caroline Testout was a fashionable French dressmaker in London who sought to buy a seedling to be named after herself in order to advertise her business. Monsieur Pernet-Ducher had once discarded as mediocre the rose that he sold her. Much to his surprise and chagrin, it became the world famous Mme. Caroline Testout.

This rose was raised from seed of Mme. de Tartas, a rose-colored Tea rose, fertilized with pollen from Lady Mary Fitzwilliam, a pale flesh-colored Hybrid Tea rose which was grown from seed raised of the Tea rose, Devoniensis, a creamy white seedling of Flavescens, and Victor Verdier, a rose-colored Hybrid Perpetual of the La Reine race.

Certain rosarians must have surmised that Mme. Caroline Testout was an outstanding parent. In 1927 Mr. H. R. Darlington wrote an article for the National Rose Society Annual in which he discussed the offspring of this rose. He gave a list of seedlings of it which were deemed worthy of naming. In the present study, 165 named varieties have been found which are offspring of this one rose. Since the parent variety is a Hybrid Tea, all but thirteen are classed as Hybrid Teas. Of these, three are Climbing

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Hybrid Teas, three are Hybrid Wichuraianas, four Hybrid Perpetual, and one each in the Hybrid China, Hybrid Lutea and Hybrid Rugosa classes. The term, Hybrid Tea, includes those roses that were formerly classed with the Pernetiana group.

In the following three tables, these offspring are listed. Table I gives those varieties which had Mme. Caroline Testout as a seed parent; table II gives those varieties which had Mme. Caroline Testout as a pollen parent; and table III gives the named sports of Mme. Caroline Testout.

Table I. Named Roses Which Have Mme. Caroline Testout as the Seed Parent.

Variety	Group	Pollen Parent
Albert James Nottidge	H.T.	Alfred Colomb
Amateur Andre Fourcaud	H.T.	Unknown
Andenken Moritz v. Frohlich	H.T.	Princesse de Bearn
Argyll	H.T.	Marquise de Sinety
Beatrix Comtesse de Buisseret	H.T.	Laure Wattine
Belle Nantaise	H.T.	Viscountess Folkstone
Bloomfield Rocket	Cl.H.T.	Ulrich Brunner
Burgermeister Christen	H.T.	Fisher Holmes
Capitaine Soupa	H.T.	Victor Verdier
Clairette Onoff	H.T.	Unknown
Clarice Juranville	H.T.	Unknown
Colonel Leclerc	H.T.	Horace Vernet
Conrad Strassheim	H.T.	Charles Darwin
Countess Cairns	H.T.	President
Dernburg	H.T.	Souv. de Rose Terelle des Chemes
Deutsche Hoffnung	H.T.	Grossherzogin Feodora von Sachsen
Domkapitular Dr. Lager	H.T.	Princesse de Bassaraba de Brancoran
Dorothy	H.T.	Unknown
Dourkap	H.T.	Unknown
Dr. F. Weigand	H.T.	Hadley
Dusseldorf	H.T.	Mme. Eugene Resal
Elisabeth Didden	H.T.	General MacArthur
Elisabeth von Reuss	H.T.	Alice Furon
Enchanter	H.T.	Alice Furon
Entente Cordiale	H.T.	Soleil d'Or
Ernest Hempel	H.T.	Unknown
Fliegerheld Boelcke	H.T.	Sunburst
Franz Pohls	H.T.	Gruss an Sangerhausen
Frau E. Weigand	H.T.	Souv. de Claudius Pernet
Frau Emmy Hammann	H.T.	Mme. Hoste
Frau Ernst Fischer	H.T.	Perle des Jardins x Mme. Eugene Resal
Frau Lilla Rautenstrauch	H.T.	Goldquelle
Frau Lina Strassheim	H.T.	Unknown
Frau Philip Geduldig	H.T.	Mme. Eugene Resal
Frau Philip Seismeyer	H.T.	Erzherzogin Maria Dorothea
Frau Therese Lang	H.T.	Johanna Sebus
Freifrau Anna von Munchhausen	H.T.	Rosel Klemm
Fursten von Pless	H.Rug.	Conrad Ferdinand Meyer
Gabrielle Pierrette	H.T.	Unknown
General Henry de Kermartin	H.T.	Reine Marie Henriette
Georges Laing Paul	H.T.	Fisher Holmes
Gladys Harkness	H.T.	Unknown
Graf Fritz Hochberg	H.T.	Goldquelle
Grange Colombe	H.T.	Lady Ashtown (?)
Grossherzog Friedrich	H.T.	Meta
Grossherzogin Marie	H.T.	Mme. Abel Chatenay
Helen Gould	H.T.	Kaiserin Auguste Viktoria
Helene Duche	H.T.	Reine Emma de Pays-Bas
Helga	H.T.	George Dickson
Helvetia	H.T.	Farbenkonigin
Herzog Carl Eduard	H.T.	Farbenkonigin
Hofgartendirektor Graebner	H.T.	Antoinette Durieu
Irene	H.T.	Mme. Jules Finger
Jeanne Liabaud	H.T.	Unknown
Karl Rosineck	H.T.	Princesse de Bearn
Konig Laurin	H.T.	White Maman Cochet
Konigin Carola	H.T.	Viscountess Folkstone
Kronprinz Wilhelm von Preussen	H.T.	Laurent Carle

Variety	Group	Pollen Parent
Kronprinzessin Cecilie	H.T.	Mrs. W. J. Grant
L'Innocence	H.T.	Unknown
La Detroit	H.T.	Bridesmaid
La Favorite	H.T.	Reine Emma de Pays-Bas
La Somme	H.T.	Rayon d'Or
Lilli von Posern	H.T.	Docteur Troendlin
Lohengrin	H.T.	Mrs. W. J. Grant
Marguerite Fischer	H.T.	Mme. Alfred Carriere
Marguerite Guillot	H.T.	Unknown
Maria Reid	H.T.	George C. Waud
Marie Isakoff	H.T.	Unknown
Marie Louise Poiret	H.T.	Marquise Litta de Breteuil
Mevrouw C. van Marwyk Kooy	H.T.	Mrs. Aaron Ward
Mevrouw del Court van Krimpen	H.T.	Prince de Bulgarie
Miss Kate Moulton	H.T.	La France x Mrs. W. J. Grant
Mlle. de Kerjegu	H.T.	Unknown
Mme. Annette Aynard	H.T.	Prince de Bulgarie
Mme. Autrand	H.T.	Prince de Bulgarie
Mme. Begault Pigne	H.T.	Her Majesty
Mme. Bernezat	H.T.	Alice Furon
Mme. Charles Lejeune	H.T.	Lady Ashtown
Mme. Edmee Metz	H.T.	Ferdinand Jamain
Mme. Edouard Herriot	H.T.	a Pernetiana
Mme. J. P. Soupert	H.T.	Alice Furon
Mme. Leon Pain	H.T.	Souv. de Catherine Guillot
Mme. Leonie Moissey	H.T.	Souv. de Paul Neyron
Mme. Marie Croibier	H.T.	Unknown
Mme. Mina Barbanson	H.T.	Mme. Abel Chatenay
Mme. Pillet	H.T.	Grace Darling
Mme. Robert Fortin	H.T.	Yves Druhen
Monsieur Faivre d'Arcier	H.T.	Xavier Olibo
Mrs. Charles E. Russell	H.T.	Mme. Abel Chatenay x Marquise Litta de Breteuil
Mrs. E. G. Hill	H.T.	Liberty
Mrs. H. G. Johnstone	H.T.	Mrs. George Shawyer
Mrs. Mina Brachanson	H.T.	Unknown
Nordlicht	H.T.	Luciole
Oberhofgartner A. Singer	H.P.	Marie Baumann
Otto Krauss	H.T.	Souv. de Claudius Pernet
Otto von Bismarck	H.T.	La France
Papa Reiter	H.T.	Unknown
Pie X	H.T.	Unknown
Prinzessin Marie	H.T.	Melanie Villermoz
Prinzessin Marie Mertschersky	H.T.	Reine Emma de Pays-Bas
Rene Oberthur	H.T.	Unknown
Rose Noble	H.T.	Unknown
Simone	H.T.	Paul Meunier
Souv. d'Helene	H.T.	Unknown
Souv. de Mme. G. Delahaye	H.T.	Xavier Olibo
Souv. de Rosieriste L. Rose Vilin	H.T.	Catherine Mermet
Superb	H.T.	Willowmere
Veluwezoom	H.T.	Soleil d'Or
Weisse Caroline Testout	H.T.	Unknown
William Askew	H.T.	Unknown

Table II. Named Roses Which Have Mme. Caroline Testout as the Pollen Parent.

Variety	Group	Seed Parent
Aimee Cochet	H.T.	Souv. de Mme. Eugene Verdier
Alberto N. Calamet	H.T.	Laure Wattine
Amateur Michel Pouget	H.T.	Frau Karl Druschki
Australie	Cl.H.T.	Mrs. W. J. Grant
Christine Wright	H.W.	**R. wichuraiana** x a Hybrid Tea
Columbia	H.W.	**R. wichuraiana**
Countess Cairns	H.T.	President
Dad Sterling	H.T.	Marechal Niel
Die Dahme	H.P.	Pierre Notting
Duchesse Hedwige d'Arenberg	H.T.	Mrs. W. J. Grant
Edmee et Roger	H.T.	Safrano
Frau Dr. Kruger	H.T.	Henriette de Loew
Frau Ernest Borsig	H.T.	Frau Syndica Roeloffs
Frau Karl Druschki	H.P.	Merveille de Lyon
Grafin Stephanie Wedel	H.T.	Dr. Grill
Grossherzogin Viktoria Mellitta	H.T.	Safrano
Gruss an Zweibrucken	H.T.	Charles Gater
Jona	H.T.	General MacArthur
Laure Wattine	H.T.	Marie Baumann
Lucien de Lemos	H.T.	Princess Alice de Monaco
Lydia Grimm	H.T.	General Jacqueminot x Kaiserin

Variety	Group	Pollen Parent
		Auguste Viktoria
Mama Gaertner	H.T.	Mme. Hoste
Margaret	H.T.	Mme. Lombard
Marguerite Moulin	H.T.	Mme. Edouard Herriot x Mrs. Aaron Ward
Marguerite Poiret	H.T.	Mme. Lombard
Mme. Joaquim Fontes	H.T.	Liberty
Mme. Kastler	H.P.	Mme. Adele Gance
Mme. Leon Simon	H.T.	Marie van Houtte
Pan America	H.T.	American Beauty
Parseval	H.T.	Dr. Grill
Professor J. Vendel	H.T.	Princesse de Bearn x Pharisaer
Purity	H.W.	**R. wichuraiana** x a Hybrid Tea
Rektor Foerster	H.T.	Golden Ophelia
Souv. d'Anne Marie	H.T.	Safrano
Unermudliche	H.China	Comtesse de Leusse
W. Freeland Kendrick	H.T.	Aviateur Bleriot
Wildenfels Rosa	H.Lut.	Frau Karl Druschki x Harison's Yellow

Table III. Named Roses Which Are Sports of Mme. Caroline Testout.

Variety	Group
Adam Rackles	H.T.
Admiral Dewey	H.T.
Arabella	H.T.
Charles de Lapisse	H.T.
Climbing Mme. Caroline Testout	Cl.H.T.
Danielle Dumour	H.T.
Docteur Troendlin	H.T.
James Ferguson	H.T.
Leon Robichon	H.T.
Maman Dental	H.T.
Maria Schmidt	H.T.
Mrs. Longworth	H.T.
Souv. de Marie Perdriolle	H.T.
Souv. du President Daurel	H.T.
White Testout	H.T

Iowa State College,
Ames, Iowa.

VANISHING ORIGINAL PRAIRIE AREA IN CEDAR RAPIDS, IOWA

George R. Bowne

This report is the result of a study during the years 1938-41. The flowering plants as well as the other vegetation are treated and the object is to establish some record of the flora on this original prairie area before the region was completely destroyed by the extensive home building program which is now in progress. The natural prairie is located in the Maplewood addition. It is approximately 40 acres in area.

Garden Grove, Iowa

A PECULIAR *POLYTRICHUM*

R. V. Drexler

This moss was collected from a wet, shaded habitat in the Quetico Provincial Park of Ontario. It has the physiogamy of an *Atrichum* but seems to be clearly related to *Polytrichum gracile* Smith. The plant differs from any *Polytrichum* species in that it has a wide leaf limb and a poorly differentiated leaf sheath. In spite of the above differences, the spinose teeth, leaf cell shape, and shape and cell form of leaf lamellae indicate a relationship to *Polytrichum gracile*. This moss may be a monstrosity due to habitat conditions.

Coe College,
Cedar Rapids, Iowa

THE STORY OF *PARTHENIUM ALPINUM*

George J. Goodman

This plant was collected in 1834 by Thomas Nuttall somewhere in the Rocky Mountains. It has never again been collected on his trail, and it is not known just where he got it. The information he gives is confusing, but it is probable that the plant was collected either in eastern Wyoming or near the Snake River plain in Idaho. The evidence for and against each of these stations is presented.

Iowa State College,
Ames, Iowa

TETRAPLOIDY IN *MELILOTUS ALBA* INDUCED BY COLCHICINE

I. J. JOHNSON AND J. E. SASS

Seedlings of sweet clover were treated with colchicine. Plants that responded to treatment either were tetraploid in all new root tissues, or had sectors, or islands of tetraploid tissue in the root tips. Cutting made from the plants in the latter category were tetraploid throughout. After the tetraploid condition is established, it can be maintained by vegetative propagation. Tetraploid plants are partially self-fertile, although considerable differences of self-fertility were found among clones originating from different treated seedlings.

IOWA STATE COLLEGE,
AMES, IOWA

THE VARIABILITY IN THE COLOR OF RED CLOVER SEEDS, ITS CAUSE, AND RELATION TO THE VALUE OF THE SEEDS

JOHN N. MARTIN

Red clover seed samples almost invariably are of three principle colors, violet or purple, yellow, and brown. The brown seeds have been pretty well proven to be considerably inferior in quality to the seeds of the other colors. Some investigators have shown the purple to be superior to the yellow both in germination and vigor of plants produced, while other investigators have data to show that the yellow seeds are equal to or superior to the purple or violet seeds.

The seeds of seven strains of Swedish origin, of six strains recommended by the U. S. Department of Agriculture and of four Iowa strains long grown on the same farms were studied as to the proportion weights, and germination of their different colored seeds.

The percentages of each color varied considerably in the same strain in different years and varied also with age of seed, and ripeness at the time of harvesting.

The percentage of brown seeds ranged from zero to 65 percent. The brown seeds were inferior in weight and in germination. The highest percentage of brown seeds was in the Kentucky strains recommended by the U. S. Department of Agriculture.

The percentage of purple or violet seeds in the different samples ranged from 16 to 62 and percentage of yellow ranged from 12 to 62. The purple and violet were slightly heavier than the yellow seeds, but there was no significant difference in germination. Seeds harvested before the heads are well ripened tend toward a high percentage of brown seeds.

The pigment determining the color of the seed is in the Malpighian layer, the outermost cell layer of the seed coat. The seeds are green previous to ripening, and pass from green to yellow and finally to purple. In case of brown seeds, the embryo which is normally white is often brown.

Iowa State College,
Ames, Iowa

SOME STRUCTURAL FEATURES OF MYCORRHIZAE ON CONIFEROUS SEEDLINGS

Andrew L. McComb and J. E. Sass

Development of mycorrhizae was found to be promoted by inoculating nursery soil with humus and top soil from well-established coniferous plantations, or by application of phosphorus fertilizer. Two types of host cell fungus relationships have been observed. In one type the root has a mantle of mycelium with abundant clamp connections. The internal mycelium is intercellular and segmented into short, straight-sided cells. The second type has a mantle of much coarser, "monilioid" mycelium. The internal mycelium is intracellular, partly peripheral along the cell walls, and segmented into rounded cells. Abundant coarse, blunt hyphae protrude into the vacuoles. In some roots the outer cortical cells contain large wefts of extremely fine mycelium. It is not improbable that two or three fungal organisms are involved, the relative prominence of each being determined by cultural treatment.

Iowa State College,
Ames, Iowa

COMPARISON OF FLORAL INITIATION IN AMERICAN-GROWN AND HOLLAND-GROWN TULIPS

J. E. Sass

The destruction of the bulb industry in the Netherlands has stimulated the production of bulbs in the United States. The question of relative flowering capacity of European and American bulbs has been raised. The flowering cycle is essentially the same in tulip bulbs from both sources; floral primordia are initiated about August first, and the bulbs enter dormancy with the pollen in late quartet stage and with ovules having little or no differentiation of the megasporocyte. Minor varietal differences occur.

IOWA STATE COLLEGE,
AMES, IOWA

CHARCOAL-ROT OF MAIZE, NEW TO IOWA

GEORGE SEMENIUK

The charcoal-rot of maize caused by *Sclerotium bataticola* Taub. was found near Ames, Iowa, during mid-August, 1941, on several prematurely dead stalks in a field of early planted corn. Greenhouse tests with the fungus produced seedling infection of maize with necrosis of the roots and mesocotyl.

BOTANY AND PLANT PATHOLOGY SECTION
IOWA AGRICULTURAL EXPERIMENT STATION
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HERITABLE CHARACTERS IN MAIZE: "ACCESSORY BLADE"

GEO. F. SPRAGUE AND J. E. SASS

A mutant character in maize brings about the formation of ridge and blade-like outgrowths on the surfaces of leaves. These accessory laminae, which are present on the partially developed leaves in the dormant embryo, arise by re-activation of vertical zones on the immature leaf. Each active zone is in effect a new marginal meristem which produces a blade-like emergence. The gene is known to be recessive, but its linkage has not yet been established.

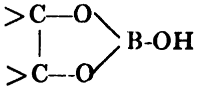
IOWA STATE COLLEGE,
AMES, IOWA

ELECTRODIALYSIS OF SUGAR BORATES

GEORGE H. COLEMAN AND AARON MILLER

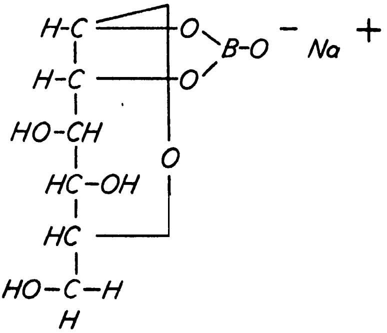
The reaction of glycols with boric acid in aqueous solutions to form an easily saponified ester has long been known. This acid ester is a stronger acid than boric acid and an increase in conductivity results.

Klein (1878) described the glycol-boric acid complex as an ester of metaboric acid. This may be represented by the following formula:



Magnanini (1890) showed that two hydroxyl groups on adjacent carbon atoms are necessary while Boeseken (1913) proved that the effect was greater if the two hydroxyl groups possessed a cis configuration as in λ-D-glucose.

The ester which is formed dissociates as a stronger acid than boric acid so it is to be expected that the addition of alkali would favor the formation of the glucose-borate ester and ionization would occur as follows:



If these formulations are correct the ions would be expected to migrate in an electrical field.

In the present work in which glucose-borax solutions were subjected to electrodialytic conditions the glucose was found to migrate preferentially toward the anode. As expected a small amount of glucose diffused toward the cathode.

The reaction between glucose and boric acid may be represented by the following equation:

$$C_6H_{12}O_6 + B(OH)_3 \rightleftarrows C_6H_{10}\,O_6{:}BOH + 2H_2O$$

The type of apparatus used was a three compartment electrolytic cell as described by Cox, King, and Berg (1929) using heavy sheet cellophane membranes. The electrodes were graphite plates for the cathode and platinum plates for the anode. Attempts to use graphite or nickel anodes were unsatisfactory due to decomposition. One hundred and ten volt direct current was used.

The results of electrodialysis experiments on glucose-borax solutions are given in Tables I and II.

TABLE I.

Electrodialysis of Glucose-Borax Solutions*

Time	*Barfoed Sugar*	*Reduction Test*
(hours)	Anode	Cathode
	Compartment	Compartment
0	Negative	Negative
4	Postive	Very slight
7	Strong positive	Very slight

*The results are only qualitative in character due to the interference of the boric acid with reduction determinations.

TABLE II.

Electrodialysis of Glucose-Borax Solutions

Time	*Observed Rotations* *	
(hours)	Anode Compartment	Cathode Compartment
0	0.00°	0.00
2	+0.16°	+0.07°
16	+1.06°	+0.32°
28.5	+1.69°	+0.43°
41	+1.91°	+0.68°
44	+2.00°	+0.82°

*The samples were withdrawn, acidified with phosphoric acid and the precipitated boric acid filtered off. The angular rotation of the filtrate was observed in a 2 dm. tube using the sodium D line as the light source.

Maltose was also found to migrate preferentially in an electrical field in the presence of borax. The results are tabulated in Table III showing the comparison between maltose borax solutions in an electrical field and in the same apparatus by diffusion only.

TABLE III.
Electrodialysis and Dialysis of Maltose-Borax Solutions

Electrodialysis			Dialysis		
Time (hours)	*Observed* Anode	*Rotation* Cathode	Time (hours)	*Observed* Anode	*Rotation* Cathode
0	0.00	0.00	0	0.00	0.00
4	+0.33°	+0.69°	11	+0.78°	+0.65°
11.5	+1.10°	+1.12°	22	+1.48°	+1.22°
23.5	+1.97°	+1.55°	36.5	+2.09°	+1.89°
29.5	+2.39°	+1.75°	59.5	+2.94°	+2.49°
51.5	+3.51°	+2.42°	84.5	+3.49°	+3.18°
76.5	+4.62°	+3.14°	111.5	+3.96°	+3.75°
Wt. of maltose at end	18.75 g.	11.12 g.		11.3 g.	12.1 g.

The electrodialysis experiments with glucose and maltose borax solutions indicate that the velocity of electrodialysis of the glucose-borate ion was somewhat greater than that of the maltose-borate ion. In an attempt to separate glucose and maltose by electrodialysis of a borax solution there was an indication of some concentration of the disaccharide. After 19 hours of electrodialysis the glucose/maltose ratio had changed from 1.43 to 1.28.

TABLE IV.
The Effect of Borax on the Determination of Sugars by Reduction

Ml. saturated borax solution added.	Other additions	Mg. glucose found.
Glucose — 800 mg. glucose in 100 ml. solution.		
0	-	795
0	-	795
10	-	628
10	-	630
10	4 ml. glycerol	720
10	8 ml. glycerol	758
10	10 ml. glycerol	786
10	10 ml. mannitol solution *	759
25	-	656
25	10 ml. mannitol solution	720
25	20 ml. mannitol solution	742
25	26 ml. mannitol solution	768
25	20 ml. glycerol	813
Maltose — reducing value, an amount equivalent in 100 mg. glucose.		
0	-	947
25	-	777
25	20 ml. glycerol	1123

*A saturated aqueous solution of mannitol was used.

Levy and Doisy (1928, 1929) have shown that sugar oxidation methods yielded erroneous results in the presence of borax. This was verified in the present work using the Lane and Eynon (1923) method for sugar determination. Addition of glycerol or mannitol raised the values for sugar found but they did not yield true values. The results are given in Table IV.

The specific rotation of D-glucose is greatly affected by borax. Murschhauser (1923) has shown that the specific rotation of D-glucose was reduced from +52.5° to +42.5° by the addition of borax. Rimbach and Weber (1905) had previously discovered that when D-glucose had stood at room temperature in a borax solution for 117 hours the specific rotation was—3.5°. They concluded that a Lobry De Bruyn interconversion had taken place.

In the present work it was found that the specific rotation of D-glucose in borax solution ranged from +52° to —8° depending upon the relative concentration of the sugar and the borax. When any of these solutions were acidified with phosphoric acid the specific rotation returned to normal. Maltose showed a slight increase of specific rotation (from +131.4° to +142.6°) upon addition of borax.

The different rotations of various concentrations of glucose in a 10% borax solution is shown in Table V.

TABLE V.

The Effect of Borax on the Rotation of Glucose

% Glucose	Observed Rotation	Specific Rotation
0.25 (in water)	+0.26°	+52°
0.25	−0.04°	−8°
0.50	−0.05°	−5°
0.75	−0.06°	−4°
1.00	−0.07°	−3.5°
1.25	−0.01°	−0.4°
1.50	+0.09°	+3.0°
1.75	+0.18°	+5.1°
2.00	+0.38°	+9.5°

On acidification of the 1.25% glucose-borax solution with sirupy phosphoric acid the specific rotation was +52°.

Addition of a small amount of solid potassium hydroxide to the 1.25% glucose-borax solution caused the specific rotation to drop to —7.6° indicating a further shift of the equilibrium with increasing pH.

The different rotations of various concentrations of maltose in a 10% borax solution are shown in Table VI.

TABLE VI.

The Effect of Borax on the Rotation of Maltose

% Maltose (hydrate)	Specific Rotation
10.0	+138.5°
7.5	+140.0°
5.0	+139.7°
2.0	+142.6°

The depression of the specific rotation of a glucose-borax solution to approximately zero while the maltose was raised slightly made it possible to calculate the concentration of glucose and maltose in an aqueous-borax solution of a mixture of these two sugars.

SUMMARY

1. Glucose and maltose have been found to migrate preferentially toward the anode in an electrical field in the presence of borax.

2. The reduction values of glucose and maltose are lowered considerably in the presence of borax. Addition of glycerol or mannitol will raise these values, but true results are not obtained.

3. The specific rotation of D-glucose is greatly affected by borax, and values from +52° to —8° are obtainable by varying the concentrations of the glucose and the borax. The specific rotation of maltose is raised slightly by the presence of borax, and will change with varying concentrations.

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THE DISTRIBUTION OF ALCOHOL IN THE TISSUES OF THE RAT

V. B. Fish and V. E. Nelson

In order to determine the distribution of alcohol in the tissues, we have devised a method which is quite simple and accurate.

The animal is killed and the tissues removed as rapidly as possible. The tissues are placed in weighed 150 ml. extraction flasks immersed in solid carbon dioxide. The flasks and tissues are weighed and the tissues covered with a solution of picric and tartaric acids. The samples are then placed in a refrigerator until the analysis can be made.

The alcohol is removed from the tissues by steam distillation using an apparatus fitted with a hashing knife attached to a motor. Any loss of alcohol is prevented by the use of a mercury seal. In this way the tissue may be hashed and the alcohol removed by steam distillation in the same apparatus hence avoiding loss of alcohol during manipulation. The distillate is received in a volumetric flask. The size of the flask depends on the amount of alcohol in the sample. The size of the flasks in our experiments varies from 25 ml. to 250 ml. and the amount of the distillate collected varies in volume from 20 ml. to 100 ml. After the distillate is diluted to volume an aliquot of from one ml. to 10 ml. is taken for analysis and transferred to the distillation flask such as is used in the analysis of blood for alcohol (Fish and Nelson, 1941). The aliquot is diluted to 10 ml. with distilled water and sodium tungstate and mercuric sulfate-sulfuric acid solutions are added as in the analysis of blood (L. C.). The mixture is distilled, five ml. of distillate being collected, and the alcoholic content determined as in the analysis of blood (L. C.).

Apparatus: The special apparatus for hashing the tissues and removing the alcohol by steam distillation is constructed in such a way that a three-hole rubber stopper which will fit the 150 ml. extraction flasks, carries a steam inlet, an outlet fitted with a trap leading to a condenser and the hashing knife. The steam inlet should reach well into the flask so that the steam is discharged below the surface of the liquid covering the tissues. The hashing knife is all metal and consists of a circular "saw toothed" knife on the end of a solid rod. The construction is such that a mercury seal prevents vapor loss. The steam outlet leading to a condenser has a trap to prevent liquids from being carried into the distillate mechanically. The other apparatus used in this work is the same as described in the analysis of blood (l. c.).

Reagents: The picric-tartaric acid solution is prepared by adding one volume of saturated picric acid solution to an equal volume of a 20 per cent solution of tartaric acid. Other reagents necessary are the same as those given in a previous paper on the analysis of alcohol in blood (l. c.).

Calculations:

$$\frac{\text{ml. water blank} - \text{ml. titration}}{\text{ml. equivalent to one ml. of standard } K_2Cr_2O_7} \times 0.5 = \text{mg. of ethyl alcohol in aliquot of sample}$$

In order to check this and other methods used in this laboratory we have used the following procedure in the preparation of standard dilute alcohol solutions: Commercial absolute alcohol is placed in a clean and thoroughly dried 50 ml. distillation flask. A small piece of metallic sodium is added and the apparatus is assembled. A similar 50 ml. distillation flask is used as a receiver. The latter flask carries a drying tube containing anhydrous calcium chloride attached to the side arm. After the reaction with sodium is complete the material is distilled and the middle one third of the distillate is collected. The alcohol is transferred to a clean, dry weighing bottle for use.

A series of small, thin walled vials should be prepared having a capillary inlet. These are weighed accurately then slightly warmed. The tip of the inlet is placed in the alcohol and as the vial cools alcohol is drawn in. To completely fill the vial the alcohol in it is heated to boiling and the inlet placed again in the alcohol. Upon cooling the vial nearly fills with alcohol. The tip of the inlet is sealed and the vial again weighed. Standard solutions are prepared by breaking the vial under water and diluting the solution to volume in a volumetric flask.

Several experiments were made in order to check the accuracy of the method. In order to do this a known amount of alcohol was added to the picric-tartaric acid solution and treated like a tissue sample. Table 1 gives some characteristic results.

TABLE 1.

Sample	Mg. of ethyl alcohol Actual	 Found
1.	3.06	3.10
2.	3.06	3.08
3.	1.83	1.85
4.	1.83	1.84
5.	0.91	0.90
6.	0.91	0.91

In other experiments definite amounts of alcohol were added to tissue samples. About half of each tissue was left untreated with alcohol and analyzed as a blank. In table 2 some of the characteristic results are given.

TABLE 2.

Tissue:	Weight of sample	Mg. alcohol added	Mg. theorectical	Mg. found	% recovery
Liver	6.224	0	-	0.03	-
Liver	6.797	6.122	6.15	6.11	99.3
Spleen	0.502	0	-	0.02	-
Spleen	0.550	3.061	3.08	3.05	99.1
Kidneys	1.474	0	-	0.03	-
Kidneys	1.494	3.061	3.10	3.06	98.8
Muscle	2.508	0	-	0.04	-
Muscle	1.885	1.212	1.238	1.24	100.2
Testes	2.630	0	-	0.06	-
Testes	3.271	1.212	1.286	1.27	99.2
Brain	0.694	0	-	0.04	-
Brain	0.681	1.818	1.858	1.846	99.4

A number of determinations were made on tissues from rats receiving no alcohol in order to determine the amount of substances normally present which appear as alcohol. Table 3 gives the average concentration of these substances determined as mg. of alcohol per 100 grams of tissue. For sake of comparison the values are given for one rat which was injected intraperitoneally with 1.4 grams of alcohol per kilo body weight and then killed after ten minutes.

TABLE 3.

Tissue:	Mg. % Alcohol		Distribution Ratio++	
	Normal	Injected+	Normal	Injected+
Liver	1.00	146.0	20	66.4
Heart	2.90	185.0	58	84.0
Brain	2.61	188.0	52.2	85.4
Spleen	4:30	234.5	86.0	105.3
Kidneys	1.35	170.5	27.0	77.5
Pancreas	1.10	82.6	27.0	37.5
Stomach (Washed)a	3.64	146.0	72.8	66.4
Small Intestine (Washed)a	1.32	71.4	26.4	32.4
Muscle	0.80	108.0	16.0	49.1
Bone	0.50	68.8	10.0	31.3
Gonads	0.83	138.0	16.6	62.7
Lungs	1.76	158.0	35.2	71.8
Blood	5.00	220.0	100.0	100.0

+Received 1.4 grams of alcohol per kilo injected intraperitoneally. The tissues were removed for analysis 10 minutes after the injection.

++The distribution ratio is the ratio between the concentration of alcohol in the tissues to the concentration in the blood. For convenience the ratio is calculated on a basis of 100 mg. per cent of alcohol in the blood.

(a) The contents of the organs were washed out with distilled water and the organ dried with a clean towel.

The distribution of alcohol in the tissues after oral administration was studied. The rats were fasted for 24 hours and then given 2.5 grams of ethyl alcohol per kilo body weight by means of a stomach tube made from a No. 8 French style catheter. The rats were anesthetized lightly using chloroform in order to insert the stomach tube and administer the alcohol solution. The rats were all free of the influence of the anesthetic within three minutes. The alcohol solution used contained 0.25 grams of alcohol per ml.

A definite time after the administration of the alcohol a blood sample was drawn from the heart and the rat killed by chloroform. The tissues were removed and the alcohol content determined. Table 4 gives the distribution ratio calculated on the basis of 100 mg. of alcohol per 100 ml. of blood. The ratios are calculated as follows:

$$\frac{\text{Alcoholic concentration in tissues (mg\%)}}{\text{Alcoholic concentration in blood mg.\%}} \times 100 = \text{ratio}$$

The ratios given are the average obtained from six rats.

TABLE 4.

Tissue:	Distribution ratio after one-half hour
Liver	68.7
Heart	41.8
Brain	21.1
Spleen	71.6
Kidneys	65.2
Pancreas	41.0
Stomach (Washed)+	1892.0
Small Intestine (Washed)+	133.0
Muscle	37.0
Bone	18.8
Gonads	46.9
Lungs	58.2

+ The contents of the stomach and intestine were washed out with distilled water and the organs dried with a clean towel.

SUMMARY

A method for the determination of the alcoholic concentration in tissues is described. This method prevents loss of alcohol during manipulation and is simple, accurate and rapid.

A method used in this laboratory to prepare accurately dilute standard solutions of alcohol is presented.

The concentration of substances in normal rat tissues reacting as ethyl alcohol has been determined and is compared with the concentration of alcohol in the tissues after the injection of alcohol.

Data are given on the distribution ratios of alcohol in tissues to the alcohol in blood 30 minutes after the oral administration of alcohol.

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Fish, V. B. and Nelson, V. E. 1941. A micro method for the determination of ethyl alcohol in blood. Proc. Iowa Acad. Sci. 48:207.

THE EFFECT OF ORAL AND INTRAPERITONEAL ADMINISTRATION OF ALCOHOL UPON THE CONCENTRATION OF ALCOHOL IN THE BLOOD OF THE RAT

V. B. Fish and V. E. Nelson

A number of experiments were made in this laboratory to determine the rate of absorption of alcohol into the blood of rats after the administration of alcohol both orally and by intraperitoneal injection. Both fasted and unfasted rats were used in these experiments.

Young mature rats were selected from the stock colonies maintained in this laboratory. The rats had been fed the stock ration which has been used successfully here for several years. In the experiments using fasted rats each rat was fasted for 24 hours preceding the administration of the alcohol. Substances normally occurring in the blood of fasted rats determined as alcohol amount to above five mg. per 100 ml. of blood. This value was assumed as the initial alcoholic concentration of the blood in these experiments.

In the experiments on the effect of oral administration of alcohol the animals were lightly anesthetized using chloroform and the alcohol administered by means of a stomach tube fashioned from a French style No. 8 catheter. The alcohol solutions used were of such a concentration that one ml. could be given for each 100 grams body weight.

Samples were taken from the external saphenous vein at 15 minute intervals for the first 30 minutes and at 30 minute intervals thereafter. The alcoholic concentration of the blood was determined by the method published in a previous paper (Fish and Nelson, 1941).

The results obtained using fasted rats were in general quite consistent. Some values for individual rats which were fasted for 24 hours and then given 2.5 grams of alcohol per kilo body weight orally are given in table I. The average values for a number of such experiments are also given.

TABLE I.

The alcoholic concentration of the blood of fasted rats after receiving 2.5 grams of ethyl alcohol per kilo body weight orally.

Time (minutes)	Mg. alcohol per 100 ml. blood			
	Rat 1	Rat 2	Rat 3	Average[+]
0	5	5	5	5
15	98	80	96	94
30	120	92	124	134
60	162	148	157	170
90	192	176	220	198
120	204	192	230	206
150	190	184	230	204
180	184	172	200	198
210	180	160	196	192
240	—	150	190	182
270	—	132	186	174

[+] The average values are the averages of these and other similar experiments.

The results obtained using unfasted rats were variable. Data given in table II are for three different rats each of which received 2.5 grams of alcohol per kilo body weight.

TABLE II

The alcoholic concentration of the blood of unfasted rats after receiving 2.5 grams of ethyl alcohol per kilo body weight orally.

Time (minutes)	Mg. alcohol per 100 ml. blood		
	Rat 1	Rate 2	Rat 3
0	5	5	5
15	90	58	90
30	186	118	120
60	218	126	108
90	224	134	90
120	206	147	78
150	188	170	52
190	—	200	—

It would appear from these results that the presence of food material in the stomach at the time the alcohol was given had a marked influence upon the rate at which the alcohol was absorbed into the blood.

The intraperitoneal injection of alcohol presents an entirely different picture. If 2.5 grams of alcohol per kilo are injected the alcoholic concentration of the blood rises more than 280 mg. per cent in 15 minutes. The rats rapidly fall into a state of coma and the blood pressure drops so low that it is difficult to obtain 0.05 ml. samples of blood from the external saphenous vein. In table III data are given obtained at several levels of injected alcohol.

TABLE III

Alcoholic concentration of blood in mg. per cent.

Time (minutes)	Amount of alcohol injected (grams/kilo)				
	1.25	1.41	1.41	1.86	2.50
0	5	5	5	5	5
10	162	140	108	226	284
30	148	140	154	266	286
60	98	124	134	240	276
90	80	114	108	213	270
120	50	100	90	203	256
150	---	80	72	196	216

Both fasted and unfasted rats were used in the injection experiments but fasting had little or no effect upon the absorption of alcohol from the peritoneal cavity. The injection of 2.5 grams of alcohol per kilo is close to the lethal dose when given in this way to the rat.

The alcohol solutions used in the injection experiments were of such concentrations that one ml. of solution was injected per 100 grams body weight.

SUMMARY

In rats fasted for 24 hours and then given 2.5 grams of alcohol per kilo orally the rate of absorption of alcohol into the blood is quite consistent in each case. Average time-concentration values are presented.

Using unfasted rats, orally administered alcohol is absorbed into the blood at differing rates.

The absorption of alcohol into the blood of rats is very rapid if the alcohol is injected intraperitoneally.

The injection of 2.5 grams of alcohol per kilo body weight is nearly a lethal dose for the rat.

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INTOXICATION TESTS—A THIRD YEAR REPORT

T. U. MARRON AND R. W. MORRISSEY

Motorists arrested for intoxication during 1939 and 1940 were classified according to the blood analyses done in this laboratory (Marron, 1941). Examination of the results indicated that the average man apprehended for driving while in an intoxicated condition had a concentration of 226 mg. of alcohol per 100 cc. of blood. It was calculated that he drank 11 to 14 ounces of whiskey, 11 to 14 bottles of 3.2% beer, or the equivalent. Ninety-two percent of those submitting to blood tests were intoxicated according to the standards of the National Safety Council. Seventy-two percent had consumed a minimum of three-fourths to one and one-fourth pints of whiskey or its equivalent in alcoholic beverages.

Since these findings were rather surprising, the records of blood alcohol determinations performed by us in 1941 were tabulated for comparison with the previous report. Table 1 shows the comparative figures.

Alcohol determinations were made by Harger titrations on distillates obtained from the blood mixed with saturated picric acid. A calculator and modified distillation apparatus for this purpose are described in another paper (Marron and Banwarth, 1942). All blood samples were drawn and preserved in accordance with the precautions found necessary (Marron, 1941a). Blood alcohol values for the average man in each class were calculated as in the previous paper (Marron, 1941).

TABLE I

Distribution of Drivers into Classes by Blood Alcohol Levels

Classes of drivers (blood alcohol mg. %)		Number of persons tested		Percent of total cases		Blood alcohol of average man in class (mg. %)	
1939-40	1941	1939-40	1941	1939-40	1941	1939-40	1941
0-387	0-491	402	326	100.0	100.0	226	232
0-149	0-149	34	25	8.4	7.7	86	118
150-199	150-199	81	165	20.2	20.2	177	179
200-299	200-299	232	197	57.7	60.4	242	242
300-387	300-399	55	36	13.7	11.0	321	329
	over 400	0	3	0.0	0.9	——	442

Comparison of the drivers of the year 1941 with the drivers tested in the preceding two years shows that they had almost identical blood alcohol concentrations. Percentages of drivers at various intoxication levels recur with precision rarely duplicated in any correlation study. Since the values cover the full range physiologically tolerable, and the samples were drawn from a relatively wide geographic area, it does not seem possible that any sort of selectivity could be responsible for the remarkable reproducibility of values in two different periods.

Consequently, these data may be made useful in traffic surveys and law enactment and enforcement.

Of those submitting to tests each year, fewer than 10% had not been drinking at all or only moderately. Twenty percent of the 90% driving in a dangerous state of intoxication had definitely passed the lower arbitrary level of 150 mg. % with an average blood alcohol concentration of about 180 mg. %. More than half (about 60%) of these drivers whose questionable ability to handle a motor vehicle was investigated had an average of 242 mg. % of alcohol per 100 cc. of blood. The remainder were in a seriously incapacitating state of intoxication.

Indications are quite definite that under our system of voluntary submission to blood tests the drinking and driving habits in the state remain constant. Similar surveys made in an area where intoxication tests have been made mandatory evidence would be proof of the effectiveness of such legislation.

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APPARATUS FOR DISTILLING ALCOHOL FROM BIOLOGICAL FLUIDS AND A CALCULATOR FOR HARGER TITRATIONS

T. U. MARRON AND C. S. BANWARTH

For the determination of alcohol in body fluids the Harger (1935) titration is extensively used with distillates obtained in various ways; e. g., by steam distillation, desiccation, distillation from picric acid, picrate-tartrate or tungstic acid. Gibson (1939) has combined it with the simple distillation from picric acid solution (Nicloux, et al. 1934) to produce an essentially satisfactory and rapid determination. Clinical simplicity with research accuracy has been achieved by the use of a specially designed distillation apparatus with the method (Johnston and Gibson, 1940). After using this method for a long period the authors have been able to revise it for still more convenience in use, and to design a calculator for obtaining the alcohol concentration in a body fluid directly from the burette readings of Harger titrations. This paper presents the revised design of the apparatus, with some modifications in use, and the calculator.

DISTILLATION APPARATUS

The distillation apparatus, Fig. 1, of Pyrex glass is particularly adapted to recovery of alcohol from body fluids after the addition of picric acid. Nevertheless, it is desirable for a variety of distillations of similar nature.

An ordinary ring stand with conventional clamps serves to hold the assembled apparatus. A micro burner is used for heating the sample flask. When the distillation has been completed the Vigreaux tube and accompanying flask are simply separated from the water condenser, which is left attached to the receiving flask. The sulfuric acid is then introduced into the distillate through the condenser, carrying all condensation in the inner tube with it. The stand and apparatus are shaken to mix the contents of the flask. After about a minute a little distilled water is used to wash the substances from the condenser into the flask. The flask can then be removed and the condenser is ready for another determination. By the introduction of acid and water through the tube that is used for condensation, the time the apparatus is in use per determination has been reduced appreciably.

The number of flasks to be supplied with the set is governed by the number of determinations to be made at one time.

The design has a number of advantages over the Johnston and Gibson apparatus. Flasks of identical volume and standard taper are more conveniently obtained and used. The standard taper joint between the Vigreaux tube and condenser facilitates the replacement of either one in case of breakage. The vapor tube in the condenser has been centered to reduce strain and awkwardness in apparatus alignment during assembly. Since addition of the acid through the vapor channel increases accuracy and precision, an air vent replaces the second condenser tube, formerly used for acid introduction.

CALCULATOR

Fig. 2 illustrates the calculator design. The materials and construction of the one in use in this laboratory are as follows:

S, U, and C scales are inked on white Bristol board, 28″ x 40″, glued to ¼″ Masonite. The S line is 21 7/8″ long, 2½″ in from the left edge and begins 3 3/8″ from the top. The U line is 21 7/8″, erected perpendicular to S. The scales on both S and U are equal and divided into 35 sections, 10/16″ each, representing 35 ml. Each subsection is subdivided into 10 units, 1/16″ in length, for 0.1 ml. values. The zero is placed at the junction of the two lines.

The mechanical device is made of 4 bars cut from steel strap, 3/8″ wide by 1/16″ thick. Bar A is 32 1/16″ long; B is 34″ long and tapered to a sharp point at one end. The two smaller bars are 14 1/16″ in length with rivet holes drilled 3/8″ from each of the ends. Rivet holes in A are 7/16″ and 18½″ from one end; in B they are drilled 3/8″ and 30 3/8″ from the square end. The two short bars are riveted to the upper surface of A at the 7/16″ and 18½″ drillings, and to the corresponding surface of B at the 12 3/8″ and the 30 3/8″ drillings, respectively. Thus, a parallel bar arrangement is formed. The rivets are just tight enough to hold any parallelogram made by hand movement of the bars. Felt pads are cemented to the under surface of the rivets to prevent scratching. Through the third hole in B the apparatus is attached to the board by riveting ¼″ above the 1 13/16″ to the right of the 35 ml. mark on line S. This rivet is loose enough to allow free motion of the bars in one plane.

Scale C is an arc of a circle marked off by the point of B as it

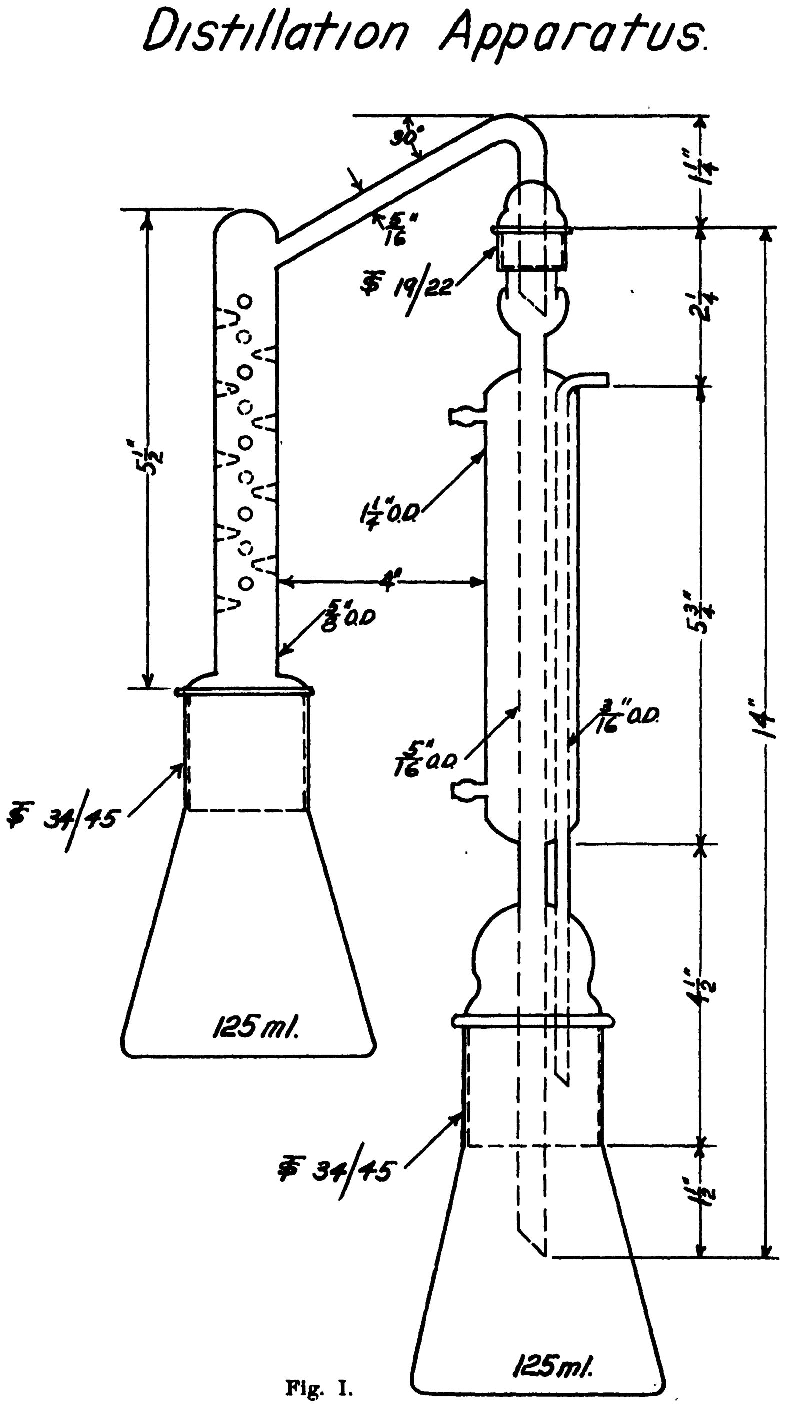
Distillation Apparatus.
30°
5/16"
₸ 19/22
1 1/4"
2 1/4
5 1/2"
1 1/4" O.D
4"
5/8" O.D
5 3/4"
14"
3/16" O.D
5/16" O.D
₸ 34/45
125 ml.
4 1/2"
1 1/2"
₸ 34/45
125 ml.

Fig. I.

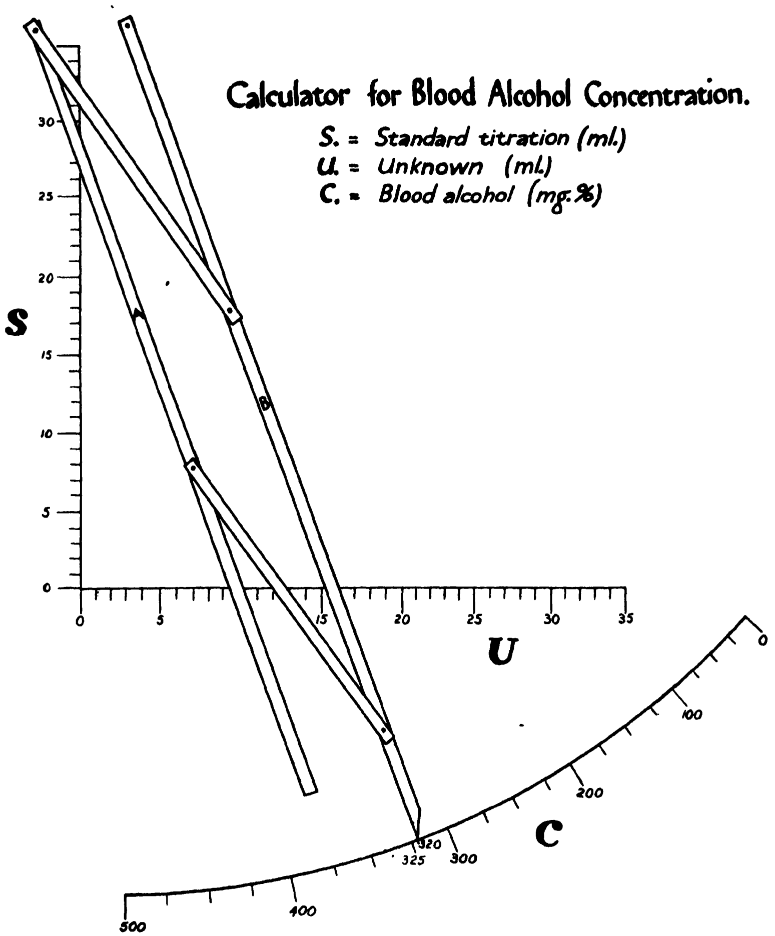
Calculator for Blood Alcohol Concentration.
S. = Standard titration (ml.)
U. = Unknown (ml.)
C. = Blood alcohol (mg.%)
S
30
25
20
15
10
5
0
0
5
15
20
25
30
35
U
A
B
0
100
200
C
320
325
300
400
500

Fig. 2

is passed over the board. The scale goes from 0, where the arc runs off the board at the right, to 500, where the point of B rests when this bar is parallel with line S. There are 100 divisions in the arc, numbered at every fifth division. Each division corresponds to 5 mg. %. For various simultaneous values of U and S the values on the C scale were calculated from the formula,

> $10(1\text{-}U/S) \times 0.5 \times 100 = \text{mg.\%}$ alcohol$=$C (Where S=ml. of red reducing fluid used to reduce 10 ml. of the standard dichromate; and U=ml. of the same fluid used to back titrate the portion of 10 ml. of dichromate not reduced by the alcohol in a distillate representing 1 ml. of sample.)

To use the calculator, bar A is placed so that its outer edge connects the standard titration value on S with the unknown titration value on U. Bar B will have followed the adjustment so that its point will rest on C at the alcohol concentration of the fluid tested.

The board is so constructed that B points to 250 when 2U = S. This arrangement is for calculations when the distillate from a 1 ml. sample of blood, urine, saliva, spinal fluid or any other fluid has been allowed to react with 10 ml. of potassium dichromate having an ethyl alcohol titre of 0.5 mg. Other aliquots used merely necessitate a division of the result by the fraction of one ml. represented by the sample. However, if the dichromate and sulfuric acid are reduced in the same proportion as the sample, as in the micro method of Marron (1940) the scale reading still gives the alcohol value directly.

The calculator will take care of Harger titrations when the ferrous sulfate-methyl orange solution used does not exceed 35 ml. for the standard. Greatest accuracy occurs in the region where 20 ml. of the reducing fluid are equivalent to 10 ml. of potassium dichromate solution (2.1288 gm./L.). Such a balance can be achieved by adding a little more ferrous sulfate solution than Harger (1935) recommends in making up the red fluid. Since the titration value of ferrous sulfate solution varies with age, it is usually added in greater or less quantity anyhow.

Readings to within 1 mg.% of the mathematical value can be obtained on the calculator. The instrument could be reduced in size by one-half or more without loss of accuracy if the mechanical part were to be cut from a plastic strip of smaller dimensions than the metal, with an etched line for accurate settings, and if the riveting were somewhat more refined.

Use of the calculator is far more rapid than figuring values from the formula, and has a time advantage over slide rule calculations. Both calculator and slide rule are used in this laboratory to check results. If either is to be used alone, the calculator is preferred because the greater simplicity of its numerical system reduces the possibilities for error in the hands of technical assistants.

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and
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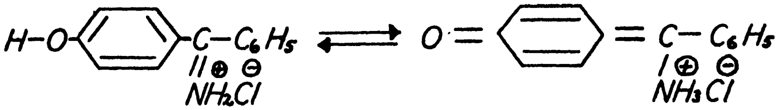
ABSORPTION SPECTRA OF KETIMINES WITH REFERENCE TO KETIMINE-ENAMINE TAUTOMERISM

J. B. Culbertson

The first reported preparation (Hoesch, 1915, 1917) of diphenyl ketimine salts in which hydroxy groups were 2- and 4- positions indicated that these compounds were unusually stable toward hydrolysis to the corresponding ketones and ammonium chloride. Subsequent studies (Culbertson, 1927, 1931) have suggested that the resistance of these phenolic ketimine salts toward hydrolysis was due to a ketimine-enamine tautomerism, or resonance, resulting in masking the ordinary reactivity of the imine (>N-H) group toward reaction with water. The proposed tautomerism may be represented as follows:



This involves a change from a benzoid-imine to a quinoid-amine structure, the latter being unhydrolyzable. Or, a resonance of the positive ion may be the stabilizing factor here. The situation is quite similar to that for auramine. The great stability of this dye toward hydrolysis to Michler's ketone, the fact that its most intense color is produced in acid solution, and spectroscopic studies have been cited in support of a quinoid-amine structure. Nevertheless, that it does have a measurable rate (Holmes and Darling, 1924) of hydrolysis indicates the presence of the benzoid-imine form in tautomeric equilibrium with the quinoid-amine. Comparative velocities of hydrolysis, colors of the free bases and salts, solubilities in various solvents, and other properties have rather uniformly suggested this tautomerism for the 2- and 4- hydroxydiphenyl ketimines. Most striking is the fact that the 2- and the 4-hydroxydiphenyl ketimine hydrochlorides are hydrolyzed much more slowly, while the 3- hydroxy compound more rapidly, than the unsubstituted diphenyl ketimine hydrochloride.

Absorption spectra in the ultra-violet have furnished additional evidence for some structure in the 2- and 4-hydroxydiphenyl ketimines different from that of the 3-hydroxy-and other diphenyl ketimines. Twelve variously substituted diphenyl ketimines have been included in this study. Absolute methyl or ethyl alcohols were used as solvents. Complete absorption in the ultra-violet was observed for all of these ketimines at 10-fold dilutions down to 0.0001 M. where selective absorption appeared. Consequently all observations were made at this concentration. In every case where a benzoid-imine quinoid-amine structure would appear possible there has been a distinct absorption band in the near ultra-violet (320 to 330 millimicrons), whereas for the others absorption was more remote in the ultra violet (250 to 270 millimicrons).

Grateful acknowledgment is given to the State University of Iowa for a summer honorarium, and to the Department of Chemistry and Dr. L. J. Waldbauer for the opportunity of using their spectrographic equipment in these studies.

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STRUCTURE OF THE HIGH-MELTING DIBROMOVERATRIC ACID

Don E. Floyd and L. Chas. Raiford

In the current edition of Beilstein's (1927) work the position of the halogen atoms in Boyen's (1888) dibromoveratric acid which he found to melt at 182°, are recorded as 2 and 5. Boyen merely determined the composition of his acid and did not even suggest a structure for it. The positions assigned for bromine seem to rest entirely on the statement of Zincke and Hahn (1903) who assumed these positions in related compounds studied by them, though they offered no definite proof. They refer for support to the work of Auwers and Müller (1902) in the same field, but the last-named workers expressly state that the position of the second nuclear bromine atom in dibromoeugenol dibromide, from which Boyen obtained his acid, is unknown.

In the study of the behavior of vanillin and its substitution products toward oxidizing agents in this laboratory, the three dibromoveratric acids demanded by theory have now been prepared by methods which establish their structures. That one having the higher melting point, 186-187°, has been compared with the acid obtained by a repetition of Boyen's work, and the products have been found to be identical. The acid prepared by our method has been shown to be the 5, 6-dibromo derivative. Detailed proof for the structure of this and the 2, 5- and 2, 6-isomers will be given.

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Zincke, T., and Hahn, O. 1903. On the action of bromine on isoeugenol. Ann. 329:1-36.

THE PREPARATION OF COLORIMETRIC STANDARDS

FERRIN B. MORELAND

In colorimetric determinations it is often found when the color is developed that the standard and unknown differ too much for accurate readings. Usually this is remedied by beginning the determination again and using a different amount of standard or unknown sample. It would be quicker to increase the color by the addition of more standard directly to the paler of the two colored solutions, if it were known that the increase in color intensity were proportional to the amount of added standard. The present investigation established the proportionality between increased color and additional standard added after color has been developed according to the usual procedure, as follows: for the determination of phosphate (Fiske and Subbarow), with an error of less than 2%; of creatinine (Folin), with an error of less than 1%; and of ammonia (preformed or from digestion of nitrogenous material) by nesslerization (Koch and McMeekin) within 5%. Uric acid added after the other reagents in the Christman and Ravwich modification of the method of Benedict and Franke, produces no color, hence the colored solution cannot be fortified in this determination.

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THE ISOLATION OF NEW ANTIOXIDANTS FROM VEGETABLE FATS[1]

CALVIN GOLUMBIC

Many vegetable oils owe their resistance to oxidative deterioration to the presence of natural inhibitors (inhibitols) such as the tocopherols. Equally important antioxygenic factors are the chroman-5, 6-quinones, the reduced forms of which have now been isolated from hydrogenated vegetable fat substrates by chromatographic adsorption on activated alumina. The adsorbed zone contained colorless antioxygenic substances, other than tocopherols, which lost their activity after acetylation but not after oxidation with ferric or gold chlorides. Concentrates obtained from the oxidized fractions, showed the qualitative chemical and spectral absorptive properties of the chroman-5, 6-quinones. The source of these highly colored o-quinones is thus their corresponding hydroquinones, 5-hydroxy tocols, and not tocopherols.

[1] Aided by a grant from Lever Brothers Company.

The chroman-5, 6-quinones have been isolated as such from incipiently rancid vegetable fats by repeated chromatographic adsorption on permutit and silicic acid, followed by saponification in the presence of sodium hydrosulfite. In the absence of this reducing agent, they were rapidly destroyed by alkali. The o-quinones which appear during the autoxidation of hydrogenated vegetable fats are not increased in amount by previous addition of synthetic tocopherol and their presence was never detected in autoxidizing animal fats containing added tocopherol. These o-quinones, their precursors (as acetates) and the chroman-5, 6-quinone prepare from synthetic a-tocopherol by nitric acid oxidation are devoid of vitamin E activity.

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FORMATION AND PROPERTIES OF SOME URETEDIONES

HARLAN B. FREYERMUTH AND L. CHAS. RAIFORD

Hofmann (Ber., 4, 246. 1871.) found that triethylphosphine served as a catalyst to cause the polymerization of phenyl isocyanate to a dimer which he designated as diphenyl diisocyanate. Staudinger ("Die Ketene", Enke, Stuttgart, 1912, p. 126.) regarded this product as a four atomic ring derivative. It has now been found that triethylphosphine polymerizes a number of substituted phenylisocyanates, such as λ- and β-naphthyl isocyanates, and p-xenyl isocyanate. These products which have more recently been listed as derivatives of uretedione, react with aliphatic amines to produce substituted biurets.

In an attempt to prepare the isocyanate of 2-amino-4-methyl-6-bromophenyl p-tolysulfonate, it was found that phosgene reacted with the amine to produce the corresponding uretedione directly. This compound had been previously prepared by Raiford and Shelton (J. Org. Chem., 4, 207. 1939.) by the action of hot pyridine on 2-carbophenoxyamino-4-methyl-6-bromophenyl p-tolysulfonate. The latter method of formation has been confirmed in the present work.

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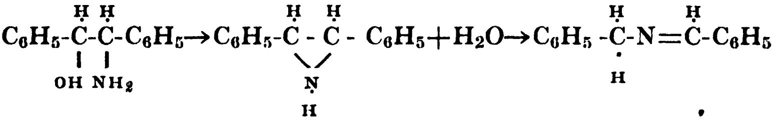
THE REARRANGEMENT OF AMINOETHANOLS

George H. Coleman and C. S. Nicholopoulos

Erlenmeyer, in 1899, found that 1, 2-diphenyl-2-aminoethanol under pyrolytic conditions and subsequent acid hydrolysis yielded benzaldehyde and benzylamine hydrochloride and proposed the following mechanism:



$$C_6H_5\text{-}\underset{OH}{\overset{H}{C}}\text{-}\underset{NH_2}{\overset{H}{C}}\text{-}C_6H_5 \rightarrow C_6H_5\text{-}\underset{\underset{\underset{H}{N}}{\diagdown\diagup}}{\overset{H}{C}\text{ - }\overset{H}{C}}\text{ - }C_6H_5 + H_2O \rightarrow C_6H_5\text{ -}\underset{H}{\overset{H}{C}}\text{-}N{=}\overset{H}{C}\text{-}C_6H_5$$

This work was repeated using standard conditions of ninety minutes and minimum experimental temperature for maximum rearrangement. This was found to be 170° for 1, 2-diphenyl-2-aminoethanol, and 180° for the isomeric iso-1, 2-diphenyl-2-aminoethanol, and 165° for diphenylethyleneimine. Benzalbenzylamine was formed in each case. These results indicate that the ethyleneimine was unstable under the conditions required for rearrangement of the aminoethanols.

The work was continued using the isomeric chloro substituted aminoetanols, $ClC_6H_4CHOHCHNH_2C_6H_5$ and $C_6H_5CHOHCHNH_2C_6H_4Cl$. On pyrolysis at 170° for ninety minutes it was found that each compound formed a mixture of two Schiff's bases. These mixtures differed markedly in percentage composition.

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TRIALKYLGOLD COMPOUNDS

Lauren A. Woods and Henry Gilman

Evidence has been found for the existence of trialkylgold com pounds. They may be prepared by the action of the alkyllithium derivatives on the corresponding dialkylgold halides.

$$R_2AuX \quad + \quad RLi \longrightarrow R_3Au \quad + \quad LiX$$

At temperatures of about a -65° these compounds are stable and may be allowed to stand for hours without decomposition.

Trimethylgold may be stabilized by such chelating agents as ethylenediamine, α-aminopyridine, and benzylamine. These complexes may be handled with moderate care at room temperature and may be analyzed. Being light and heat sensitive they will decompose over a period of weeks or less even when under refrigeration and protected from light.

Trialkygold compounds at a temperature of about a -65° may be cleaved with hydrogen chloride in anhydrous ether to give the corresponding hydrocarbons and dialkylgold halides. This fact has been utilized in an improved preparation of dialkygold halides from gold tribromide and the desired alkyllithium compounds.

AMES, IOWA

PREPARATION AND STABILITY OF DIPHENYL AMINE HYDRONITRATE

ROBERT E. JONES AND J. B. CULBERTSON

In connection with certain proposed studies the question of the preparation of diphenyl amine hydronitrate, or diphenyl ammonium nitrate, arose. A search of the literature revealed no record of this substance. The nearest equivalent reported was the perchlorate salt of diphenyl amine (Ber. 43, 1085-86. 1910). This compound was obtained upon treatment of a carbon tetrachloride solution of the amine with 70% perchloric acid added dropwise.

Aside from the fact that salts of diphenyl amine are very largely hydrolyzed in any aqueous media, at the outset it was recognized that the formation of a nitrate salt would be further complicated not only because of the strongly oxidizing character of the nitrate radical but also because of the nitrating property of concentrated nitric acid.

After a number of preliminary experiments involving various dilutions, a concentration of 0.25 M. pure (practically 100%) nitric acid in carbon tetrachloride was added dropwise to a 0.5 M. solution of diphenyl amine in the same solvent. The temperature was kept at -15° C. while the solution was thoroughly mixed by mechanical stirring. The nitrate salt separated at once as a yellowish-colored amorphous solid. The product was quickly filtered with suction and washed thoroughly with cold carbon tetrachloride. This material had a light yellow color, no doubt due to traces of impurity. It was subjected to analysis for nitrogen according to the usually modified Kjeldahl procedure applied to organic compounds containing oxidized nitrogen. Duplicate results gave 11.73% and 11.89% nitrogen. The theory for diphenyl amine hydronitrate is 12.07% nitrogen.

On standing for several days, the light yellow material acquired a dark greenish-blue color, later becoming practically black. Presumably this color change was due to intra-molecular oxidation and nitration giving a mixture of products very difficult to identify.

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RING CLOSURE OF N-METHYLCYCLOHEPTYLAMINE

GEORGE H. COLEMAN AND JOSEPH J. CARNES

Previous work in this laboratory has shown that secondary N-chloroalkylamines lose the elements of hydrogen chloride to form heterocyclic amines when heated in sulfuric acid solution. This reaction has now been applied to the preparation of the bicyclic compound tropane (8-Methylazabicyclo [3, 2, 1] octane).

N-Methylcycloheptylamine was prepared from cycloheptanone and methylamine by condensation and reduction of the resulting imine. This compound formed 85-95% yields of the chloromine when treated with chlorine. The N-chloro-N-methylcycloheptylamine when heated at 65°-67° in 84% sulfuric acid gave tropane in 40-42% yields. This was identified by its physical constants and by the melting points of the picrate, chloroplatinate, and chloroaurate.

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STABILITY OF CYSTEINE SOLUTIONS

RONALD E. PYLE AND JOSEPH I. ROUTH

The stability of cysteine in acid solution increased with increase in acidity (0.1 to 6N HC 1). When the solutions were made in conductivity water and stored under nitrogen, less than 1 per cent of the cysteine was oxidixed in 7 days.

Cysteine did not appear to be oxidized when it was subjected to the conditions obtaining in the hydrolysis of proteins by acids. Treatment of cysteine solutions with decolorizing charcoal produced extensive oxidation to cystine. During similar treatment with kaolin no appreciable oxidation occurred.

When cysteine was added to proteins and the mixture was subjected to acid hydrolysis only about half (40 to 70 percent) of the added cysteine could be recovered even when kaolin was used as a decolorizing agent. Since cysteine added to a protein hydrolysate can be completely recovered the exposure of cysteine to hydrolyzing conditions in the presence of protein is probably responsible for its destruction. The figures given for the cysteine content of proteins must be regarded as minimal and cysteine probably occurs more widely in proteins than is ordinarily believed.

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INTERMEDIARY METABOLISM OF HISTIDINE

Robert Crookshank and Clarence P. Berg

The two optical isomers of β-4-imidazolelactic acid were prepared from the *d*-and *l*- histidine monohydrochlorides by means of silver nitrite. These were fed in diets containing casein hydrolysates from which the histidine had been removed by precipitation as the silver salt (Hydrolysate A) or as the mercuric sulfate complex (Hydrolysate B). Slow to moderate growth was obtained in rats fed diets containing Hydrolysate A when supplements of either *l*- or *d*- imidazolelactic acid were added; growth in the former instance was greater than in the latter. Rats fed the unsupplemented diets failed to grow. When the diet contained Hydrolysate B, supplements of *l* imidazolelactic acid did not promote growth, but supplementation with histidine did. A precipitate was obtained by subjecting Hydrolysate A to the procedure used for preparing Hydrolysate B. When this precipitate was freed of mercury and sulfate ions and added to diets containing Hydrolysate B and imidazolelactic acid, growth occurred.

Further studies are being conducted.

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AN APPARATUS FOR THE STUDY OF THE KINETICS OF THERMAL DECOMPOSITIONS

R. B. Anderson, H. H. Rowley, and R. F. Makens

For kinetic studies accurate control of the temperature of the reaction flask is required. The reaction flask was placed in a furnace which was constructed in a large metal container A (Fig. 1). Forty-four turns of #22 nichrome wire were wound about a 12"x4½" refractory cement core. To insure uniform distribution of heat, the flask was immersed in a bath of molten tin. The tin was contained in an iron crucible C constructed by welding a bottom on a large iron pipe. The temperature of the molten tin was determined with a chromel-alumel thermocouple E of twenty alternate hot and cold junctions. Each hot junction was enclosed in a Pyrex tube which was held in place by a metal clip G. A sturdy clamp H was required to hold the reaction flask in the molten tin. For temperature regulation of the furnace, the control of Zazel and Hancox, 1934, was used. Variations of the E. M. F. of the thermocouple produce deflections of a mirror galvanometer. This causes a beam of light from a spotlight to move off or onto a photo-electric cell producing phase variations which control a Thyratron tube. In this manner the current of the furnace circuit can be changed by 0.7 ampere, and a temperature control of ±0.3°C. can be obtained in the range 300-400°C.

The reaction system was a variation of a general type for studying a decomposition involving gases which are noncorrosive to mercury as described by Thompson and Frewing, 1935. It consisted of a reaction flask R (Fig. 2) which communicates by capillary tubing to a capillary mercury manometer M, and to the remainder of the system by stopcock A. Since the compounds studied were liquids at room temperature, the capillary manometer, capillary tubing, and manifold were heated to 95°C. to prevent condensation in the tubing or stopcocks; this is indicated by sectioning in Fig. 2. For this purpose the tubing was wound with nichrome wire, and the stopcocks were provided with mercury seals to prevent leakage at this temperature.

The heated capillary manometer M was connected to an open end differential manometer D. The levels of the capillary manometer were equalized, and the pressure was read on the manometer D.

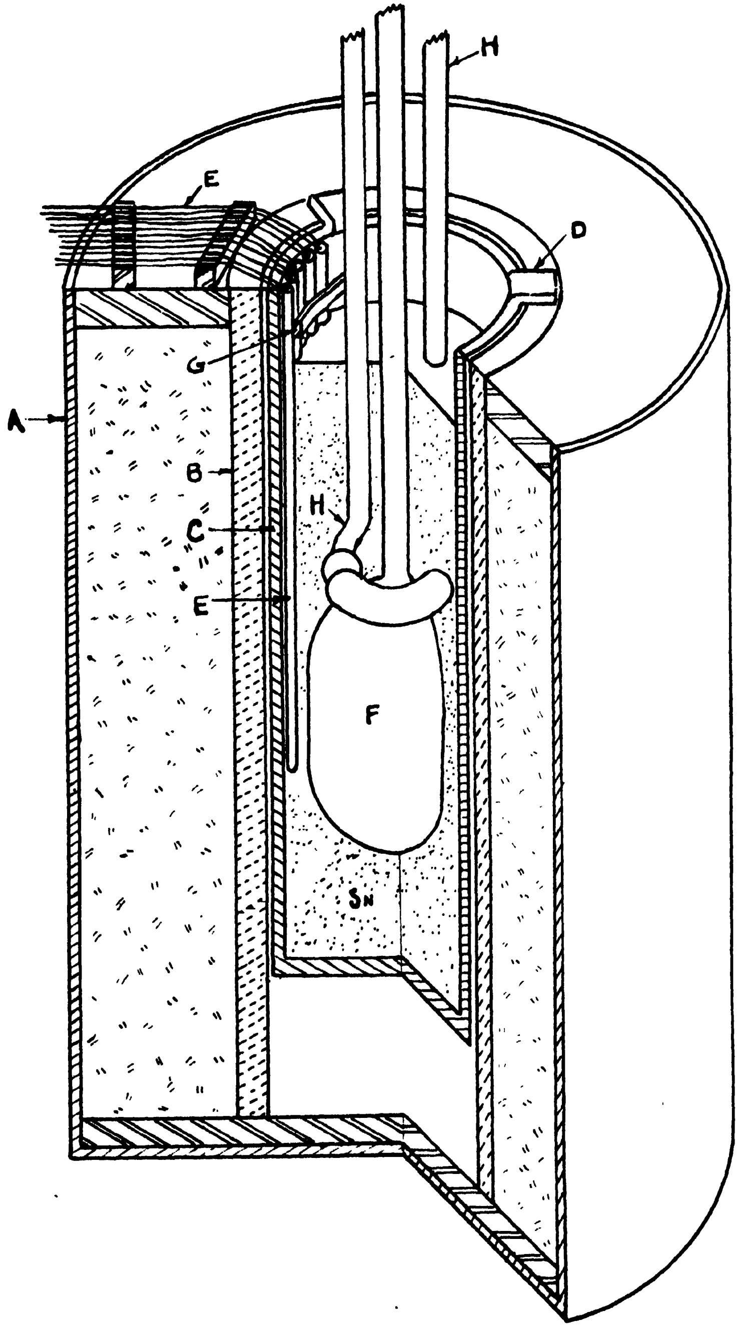

Fig. 1. The furnace and reaction flask

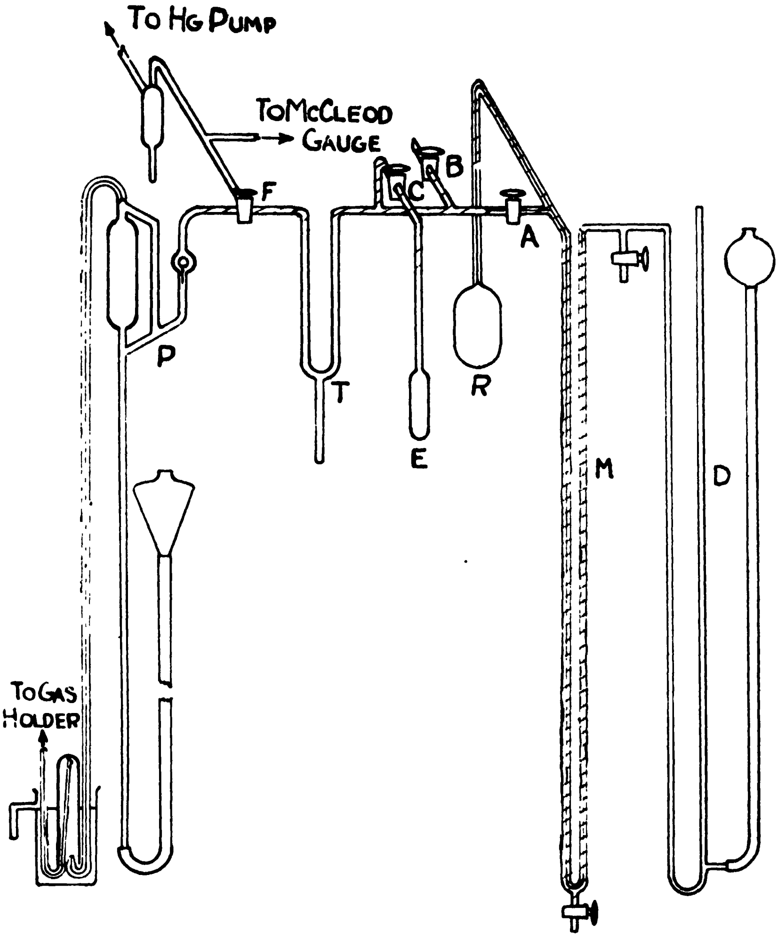

Fig. 2. The reaction system

For evacuation the system was provided with a large mercury diffusion pump backed by an oil pump. Bulb E, which contains the reactant was placed in an acetone-dry ice bath, and the system was evacuated with stopcocks C and A open until a pressure of less than 0.1 micron was attained. Stopcock F was turned to disconnect the part of the system to the right of this stopcock from the mercury and Toepler pumps. Bulb E and trap T were warmed, and the reactant was distilled into the reaction flask R to a desired pressure set upon the manometers. Stopcock A was immediately closed, and this was taken as zero time. The changes of pressure can be followed by the manometers.

The contents of the reaction flask may be removed at any desired time with the Toepler pump P, and transferred to a gas holder. Liquids and gases with high boiling points may be condensed in trap T by using suitable cooling mixtures.

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RAMAN EFFECT OF SODIUM CYANIDE

GEO. GLOCKLER AND H. T. BAKER

In another study we wished to use the Raman line of sodium cyanide solution as a reference spectrum. We find that potassium cyanide solutions but not sodium cyanide have been studied by Pal and Sen Gupta (1930). It is well known that electrolytes which are strong salts and hence highly ionized in solution give Raman lines only of their ions in case the latter are complex. Hence only the Raman spectrum of the cyanide ion is to be expected from any cyanide solution independent of the positive ion. Only one frequency should be observed due to the vibration of the carbon and nitrogen atoms relative to one another. However Pal and Sen Gupta reported two frequencies: 838 and 2080 cm^{-1}. From studies on other cyanides such as hydrogen cyanide (Hibben, 1939) the higher value evidently belongs to the carbon-nitrogen vibration in the cyanide ion. The lower frequency must therefore be spurious in some way. The first idea that always comes to mind at this juncture is the possibility that the given frequency has been deduced by the use of a wrong exciting line. However we convinced ourselves speedily that this error could not have been made. The next possibility is the search for an impurity which might give rise to a low vibration (838 cm^{-1}). It was indeed found that potassium cyanate has a frequency of just this value and it seems clear that this line is due to the presence of a small amount of cyanate in the cyanide used. This impurity could easily arise by gradual oxidation of the initial cyanide by the oxygen of the air. In order to be certain of our contention we measured the Raman spectrum of sodium cyanide solutions.

Experimental Results. An approximately saturated solution of sodium cyanide (C.P.) in water was prepared by dissolving 465 gms. of the salt per liter of solution in accordance with the solubility determination of Kireev and Vagranskaya (1935). The solution was actually used at 25°C and hence no difficulty was encountered because of precipitation. The solution gave a bright Tyndall beam of greenish blue color. It also gave a decided background on the photographic plate in the region 4358 to 4916 angstroms. However filtering several times through animal charcoal and Fuller's earth cut down the intensity of the Tyndall beam considerably and resulted in very little background in the above mentioned region. It was now possible to obtain a clear, sharp Raman line of 2086.7 cm^{-1} (Table I). No other line was found on any of our plates.

The Force Constant. Since the frequency of the CN-Bond appears now to be known it seemed of interest to calculate the force constant (k):

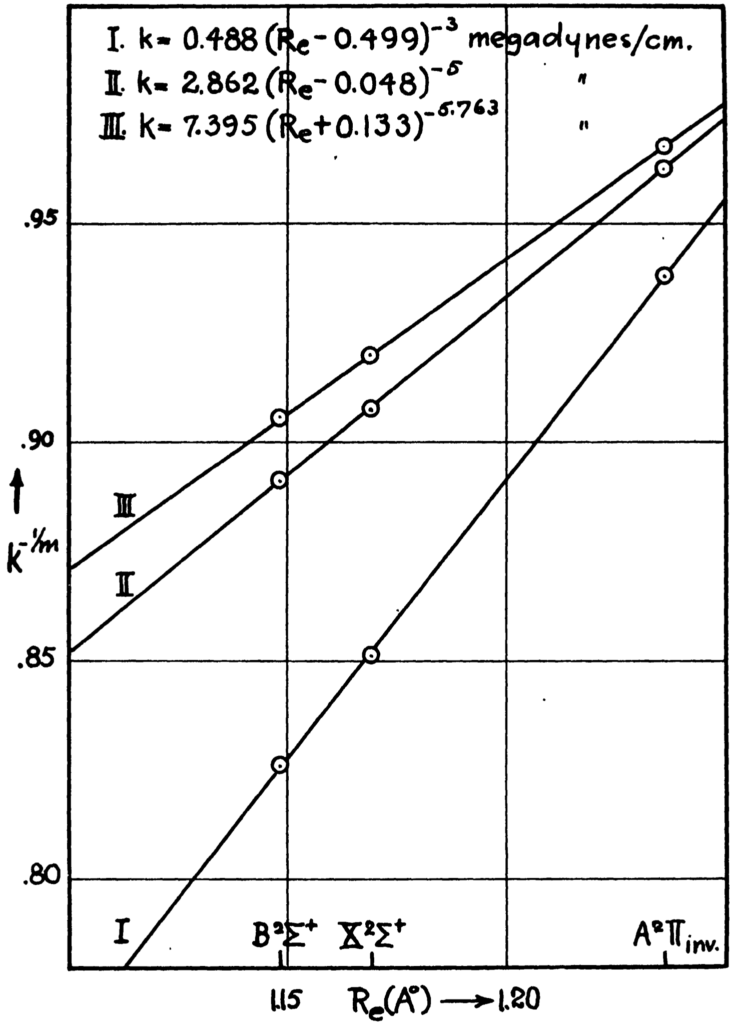
$$k = 0.05863\ \mu\omega^2 = 1.65 \times 10^6 \text{ dynes/cm} \qquad (1)$$

where μ is the reduced mass of the cyanide radical on the atomic weight scale (C = 12, N = 14) and ω is the frequency in wave numbers. This value is for the cyanide ion in solution. For comparison we have calculated the force constant of the CN-group in various spectroscopic states taken from Jevons (1932) and of several other compounds containing the CN-group. The frequencies were taken from Hibben (1939) and the results are given in Table II. An application of Badger's (1934, 1935) rule which is an empirical relation between the force constant and the equilibrium inter atomic distance (R_e) is shown in Figure I. The three spectrosscopic states ($B^2\Sigma^+$, $X^2\Sigma^+$ and $A^2\pi_{inv}$) are used to determine the straight line connecting $k^{-1}/^3$ and R_e. If the same relation holds for the CN-group in other molecules, the respective interatomic distance can be obtained graphically or from the equation

$$k = 0.488\ (R_e - 0.499)^{-3} \text{ megadynes/cm} \qquad (2)$$

The values of R_e are shown in the fourth column of Table II. The attempt to compare these distances with other data is rather unsuccessful. Electron diffraction experiments cited by Brockway (1936) are not extensive enough and not of sufficient high accuracy to permit a decision to be made. In cyanogen and methyl cyanide the empirical rule values are lower than the electron diffraction values. It is to be hoped that the latter method can be developed to a higher degree of precision so that the present application may be tested.

Potential energy curve. In a further attempt to make use of the vibration frequency it is always interesting to construct a potential energy curve, because the second derivative of the potential energy in respect to distance of separation evaluated at the equilibrium distance is the force constant. The most satisfactory curve of this kind is the Morse (1929) curve. It is entirely empirical but the Schroedinger's equation can be solved (Hellmann, 1937). Lately Born and Mayer (1931) have employed a potential energy curve for crystals which has a power term for attraction and an exponential repulsive term. This mathematical structure is more sat-



Force Constant of Cyanide Radical and internuclear distance

isfactory on the basis of modern considerations and we have adopted this form of expression for the present case:

$$U(R)/D = 1 - 2(R_e/R)^m + \exp(-B(R - R_e)) \quad (3)$$

U(R) is the potential energy of the system when the atoms are a distance R apart. One of the atoms is located at the origin. D is the heat of dissociation. R_e is the equilibrium distance, m is a numerical exponent and B is a constant. The function is unsatisfactory near R equals zero, where it approaches a negative infinite value. However this region is of no importance in our considerations. Differentiation of (3) yields

$$dU/dR = 2DR_e^{m} \cdot m\, R^{m-1} \cdot R^{-2m} - DB \exp(-2B(R-R_e)) \quad (4)$$

This quantity (the force between C and N) must be zero when $R = R_e$:

$$_{Re} \quad 2Dm/R_e \ - \ DB; \quad B = 2m/R_e \quad (5)$$

The second derivative evaluated at $R = R_e$ yields the force constant k:

$$k = 2Dm(m - 1)/R_e^2 \quad (6)$$

The value of the exponent m can be obtained from the spectroscopic data of Jevons (1932) who also gives the heat of dissociation. The values of m so calculated are given in Table II (column 7) and their average is

$$m = 3.763 \pm 0.121 \ (\pm 3.2\%) \quad (7)$$

If we assume that this value is constant for the CN-group in combination with other atoms and radicals we can calculate the heat of dissociation (D) from the force constant (k) and the equilibrium distance (R_e):

$$D = 3.0\ KR_e^2 \quad (8)$$

D is given in electron-volt, k is megadynes per cm and R_e is expressed in angstroms. The calculated values are given in Table II (column 8). Sutherland (1938) studied a potential energy curve containing two inverse power terms. As stated above the present case seems more satisfactory on the basis of modern concepts (Born and Mayer, 1931). Expression (3) can be rewritten

$$V = U(R) - D = -aR^{-m} + b\exp(-R/c) \quad (10)$$

where a, b and c are constants. If a is nearly the same for the

TABLE I

Raman Line of Cyanide Ion
(4358A° Hg excitation)

Plate	cm-1
I	2089
II	2084
III	2083
IV	2092
V	2087
VI	2085

Average: 2086.7 ± 2.7 cm-1

TABLE II
Equilibrium Distance and Heat of Dissociation of the CN-group

Compound	ω cm^{-1}	k x10-6	Equilibrium Distance= R_e (A°)			m	D(e.v.)	
			(1)	(2)	(3)		calc.	expt.
$(CN)_2$	2334	2.064	1.117	1.117	1.16±.02	3.763	7.73	—
CH_3CN	2250	1.918	1.132	1.132	1.16±.02	3.763	7.36	—
CN ($B^2\Sigma^+$)	2164.15	(1.774)	(1.148)	(1.148)	—	3.944	7.01	6.30
HCN (liq)	2096	1.664	1.163	1.163	—	3.763	6.75	—
HCN (gas)	2089	1.653	1.164	1.165	—	3.763	6.72	—
NaCN (soln)	2086.7	1.650	1.165	1.165	—	3.763	6.71	—
NaCN (cryst)	2085	1.647	1.165	1.166	—	3.763	6.71	—
KCN (soln)	2080	1.639	1.166	1.167	—	3.763	6.69	—
CN ($X^2\Sigma^+$)	2068.79	(1.621)	(1.169)	(1.169)	—	3.666	6.65	7.09
CN ($A^2\pi$inv)	1788.66	(1.212)	(1.236)	(1.236)	—	3.679	5.54	5.74

(1) from empirical rule (Badger). (2) from empirical inverse fifth power rule.
(3) from electron diffraction experiment.

CN-group in its various states, k can be written

$$k = \text{const. } R_e^{-(m + 2)} \qquad (11)$$

with m = 3 we find that

$$k = 2.86 \times 10^6 (R_e - 0.048)^{-5} \qquad (12)$$

Calculated values of R_e are shown in Table II (column 5). The basic values of the spectroscopic states ($B^2\Sigma^+$, $X^2\Sigma^+$ and $A^2\pi_{\text{inv}}$) give a straight line as is the case with Badger's rule. However on purely mathematical grounds an inverse fifth power relation should yield nearly a straight line if an inverse third one does. Hence neither is to be preferred. An inverse 5.763 power relation gives a somewhat better straight line than the other values of m (3 or 5).

It is evident that these studies if carried out with greater precision will permit the determination of atomic radii and heats of dissociation of bonds in molecules.

Summary. The fundamental frequency of the CN-group is 2086.7 cm^{-1}. A lower frequency of 838 cm^{-1} obtained by earlier investigation is due to the cyanate ion present as an impurity. The force constant of the cyanide ion is 1.65. megadynes per cm. A comparison is made of the force constants of the CN-group in various molecules and spectroscopic states and the internuclear distance. Badger's rule holds. A potential function is discussed and the exponent of the repulsive term is found to be 3.763 ± 0.121 from band spectrum data. The heat of dissociation of the CN-group is calculated from the force constants, the equilibrium distance obtained from the inverse third power rule and the average value of the repulsive exponent.

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SYSTEMS OF CHEMICAL COMPOUNDS

Geo. Glockler

Introduction: The nitrogen system of chemistry is well known through the work of Franklin (1935) and others and the numerous relations existing between the nitrogen and oxygen systems of compounds, are illustrated by many examples in the monograph just cited.

Isoelectronic system: It has been found that these relations can most easily be seen on the basis of a table first given by Grimm (1925) of isoelectronic systems of radicals and atoms. Grimm used the term pseudo-atom for radicals isoelectronic with the parent atom. For example methine (CH) is a pseudo-atom of nitrogen and methane (CH_4) is a pseudo-atom of neon. The properties of radicals and atoms so related are very often closely alike. That methane is rare-gas-like has been shown earlier (Glockler, 1926). The table of pseudo-atoms as rendered by Grimm has been extended to include boron and its hydrogen containing radicals (Glockler, 1928). In Table I this extension is added in the last horizontal row. It can be seen that a system of boron-hydrides should exist and of course it is known through the work of Stock (1933) and Schlesinger (1931). The addition of neon-hydride ion $(NeH)^+$ to Grimm's original table is quite logical as such rare gas hydride ions have been found in the mass-spectrograph (Bainbridge, 1933; Lukanow and Schutze, 1933; Bainbridge and Jordan, 1936).

The nitrogen and oxygen systems: The relationships existing between these two systems of chemistry are readily understood on the basis of the table of pseudo-atoms. Groups in the same vertical column possess similar electronic structure and may be expected to replace one another. The various systems of chemistry are given by the horizontal lines. From the right middle portion of the table we can see that NH_3, NH_2, NH are to be replaced in the water or oxygen system by H_2O, OH and O respectively. In any given compound there is usually a central atom around which these radicals are located. It is quite obvious that a great deal of information can be systematized by using this portion of the table.

Equivalent groups: The usefulness of the table may further be extended by adding the portion to the left of the diagonal center line containing the atoms. The question may be asked: What group in the water system is equivalent to the nitrogen atom itself? To answer this question one reasons as follows: It is noted that the right half of the table is constructed by adding hydrogen atoms to the group in the preceding column. Similarly removing hydrogen atoms from any one group, produces the radical or atom to the left of the given structure. In order to obtain the oxygen equivalent of the nitrogen atom, one would have to remove one hydrogen atom from the oxygen atom itself. This cannot be done without destroying it. However we can get the oxygen equivalent of the nitrogen atom in an indirect manner.

It is well known that the hydrolysis of nitriles leads to carboxyl-group formation:

$$\text{-CN} + 2H_2O \longrightarrow \text{-COOH.NH}_3$$

From this reaction we see that the grouping O(OH) is equivalent to the nitrogen atom. This point can be shown further by considering the carboxyl group -COOH and writing it in the ammonia system as -C(NH)NH_2. Since it is always possible to add or subtract appropriate solvents molecules, -C(NH)NH_2 can be written as $\text{-CN} + NH_3$. In this manner the equivalent groups in the left half of the table have been constructed.

Similar tables of pseudo-atoms and equivalent groups have been found useful for the other rows of elements of the periodic system. (Tables II to IV). In going from left to right in any one row, hydrogen atoms are added, one by one, and a complete hydride molecule is removed as soon as it occurs. For example, Sb_2H_2 and H give Sb_2H_3 or $Sb + SbH_3$ leading to Sb in the next column (see Table IV). With the help of these tables it is an easy matter to study and correlate reactions in the various systems of chemistry. For example the following oxydation-reduction reactions of the ammonia system are more readily understood when the water-equivalents are known:

$KCN + KNH_2 \rightarrow K_2CN_2 + N_2$ (NH_3 system)
$KCOOH + KNO_3 \rightarrow K_2CO_3 + HNO_2$ (H_2O system)
$KCN + 2C_2N_2 \rightarrow KC_2N_3 + C_3N_2$ (NH_3 system)
$KCOOH + (COOH)_2 \rightarrow KHCO_3 + CO_2 + 3CO + H_2O$ (H_2O system)
$KCN + Cl.NH_2 \rightarrow KC_2N_3 + KCl + NH_4Cl$ (NH_3 system)
$KOH + KCOOH + ClOH \rightarrow K_2CO_3 + HCl + H_2O$ (H_2O system)

It is of course not to be expected that the course of reaction should be exactly the same in the two systems. The general relations are however most obvious on the basis portrayed above.

Summary: The various systems of chemistry such as the ammonia or nitrogen system and the water or oxygen system can best be studied on the basis of isoelectronic radicals and corresponding

TABLE I

						Na^+
					Ne	NeH^+
$5F$	$4F$	$3F$	$2F$	F	FH	FH_2^+(?)
$2O + OH$	$2O$	$O + OH$	O	OH	OH_2	OH_3^+
$N + NH$	$N + NH_2$	N	NH	NH_2	NH_3	NH_4^+
$CH + CH_2$	C	CH	CH_2	CH_3	CH_4	CH_5^+
B	BH	BH_2	BH_3	BH_4	BH_5	BH_6^+

TABLE II

				A	KH^+
$4Cl$	$3Cl$	$2Cl$	Cl	ClH	ClH_2^+
$2S$	S_2H	S	SH	SH_2	SH_3^+
P_2H_2	P	PH	PH_2	PH_3	PH_4^+
Si	SiH	SiH_2	SiH^3	SiH_4	SiH_5^+

TABLE III

					Rb^+
				Kr	KrH^+
$4Br$	$3Br$	$2Br$	Br	BrH	BrH_2^+
$2Se$	Se_2H	Se	SeH	SeH_2	SeH_3^+
As_2H_2	As	AsH	AsH_2	AsH_3	AsH_4^+
Ge	GeH	GeH_2	GeH_3	GeH_4	GeH_5^+

TABLE IV

					Cs^+
				Xe	XeH^+
$4I$	$3I$	$2I$	I	IH	IH_2^+
Te_2	Te_2H	Te	TeH	TeH_2	TeH_3^+
Sb_2H_2	Sb	SbH	SbH_2	SbH_3	SbH_4^+
Sn	SnH	SnH_2	SnH_3	SnH_4	SnH_5^+

atoms. The usual tables of these isoelectronic systems or pseudoatoms are extended and these new arrangements show many interesting relationships between the various systems of chemical compounds.

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REPRESENTATION OF EQUILIBRIUM CONDITIONS FOR THE CARBON MONOXIDE—CARBON DIOXIDE —STEEL SYSTEM.

H. A. Wilhelm and C F Gray

Proper conditioning of atmospheres for carburizing, for heat treating, and for carrying out other high temperature metallurgical processes depends in general on control of each system with regard to its equilibrium conditions. In connection with steel processing, numerous investigations have been made to determine equilibrium conditions for the most common gas-steel reactions. One such reaction that has been studied extensively takes place when certain mixtures of carbon monoxide and carbon dioxide come in contact with ordinary carbon steel at elevated temperatures. The purpose of this paper is to review some of the methods that have been used to represent equilibrium for this gas-steel reaction and to present a condensed but more comprehensive treatment of equilibrium for the system.

Although differences of opinion exist regarding the actual state of combination of the carbon in steel and regarding the mechanism of the chemical process involved, the equation which is generally used to represent the reaction under consideration is

$$(1)\quad Fe_3C + CO_2 \rightleftarrows 3Fe + 2CO.$$

Here the carbon in the solid state is assumed to be combined with iron and exists as such in solid solution throughout the austenite range of the iron-carbon phase diagram. Whether we do or do not accept this equation as proper representation of the mechanism, the number of variables for the system corresponds to this equation and it will therefore be used in the discussion of the treatment of results of studies on this equilibrium.

An analysis of equation (1) shows that equilibrium depends on a number of factors. In general, temperature change has a very definite influence on chemical equilibrium except in the special case where the heat of reaction over the temperature range is zero or nearly so. Available data show that we are not dealing with such a special case here so temperature must be definitely considered in any treatment of the carbon monoxide-carbon dioxide-steel system. In accordance with the principles of Le Chatelier a change in the total ($CO+CO_2$) gas pressure will tend to drive the reaction one way or the other depending upon the change. The partial pressures of the gases and the composition of the gas phase are related to the total pressure and tend to vary with it to maintain equilibrium. Furthermore, it has been shown experimentally that when only one solid phase (austenite) exists, the composition of the gas phase in equilibrium with a steel depends also on the carbon content of the solid phase and vice versa even though constant temperature and constant total pressure are maintained. Complete representation of equilibrium conditions for the system involving only the one solid phase requires then specification of the four variables, total pressure of the reactive gases, composition of these gases, composition of the solid phase (or the equivalents of these three) and temperature. More specifically the equilibrium constant in terms of activities gives for equation (1) the relation

(2)

$$K = \frac{A_{Fe}^{3}}{A_{Fe_3C}} \qquad \frac{A_{CO}^{2}}{A_{CO_2}}$$

For the two phase system, it is evident that specification of all four of the above variables is necessary in order to fix these activities and define the equilibrium.

Investigators have graphically represented the relation between the variables of this system in a number of ways. In practically all cases, however, at least one of the variables is held constant and the graphs, usually consisting of a number of lines, relate the other three variables. Grossmann (1938) has used the data reported by Bramley and Lord (1932) to construct the isotherms of Fig. 1. As an example of the interpretation of these curves, the gas in equilibrium with a steel containing 0.5% carbon at 900°C is approximately 4.5% CO_2 and 95.5% CO when the total (CO_2+ CO) pressure is one atmosphere. In their article, referred to above, Bramley and Lord reported results of work for eight different total pressures ranging from one-fourth of an atmosphere to two atmospheres. Figure 1 is for a total pressure of one atmosphere only. To represent their data completely by this form of graph would require seven more figures constructed on the same plan as Figure 1, each one being for a different value of the total pressure.

Takahashi (1926) represented his data on this system by a series of isotherms similar to Fig. 1. By his method, represented in Fig. 2, allowance is made for changes in the number of solid phases at the boundaries of the austenite area of the iron-carbon phase diagram. Here again only one total pressure, one atmosphere, is represented and a series of such figures would be required to represent equilibrium conditions for a series of total pressures.

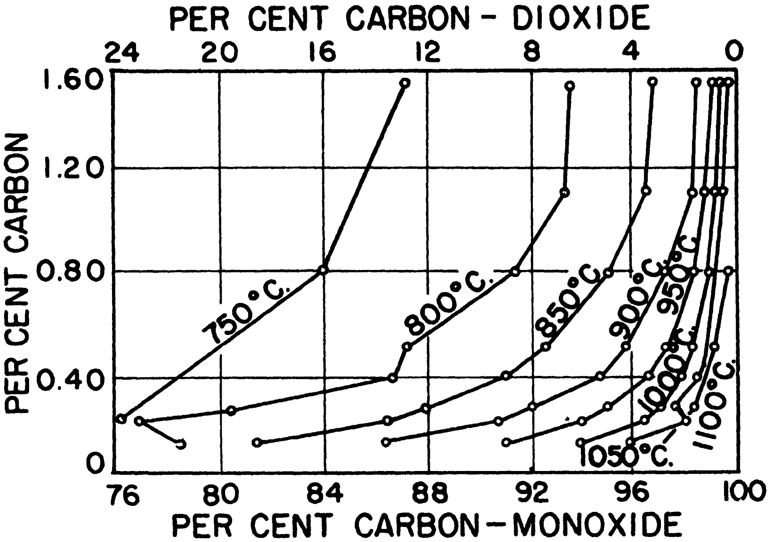

Fig. 1. Isotherms showing equilibria between various CO-CO_2 mixtures and iron with various carbon contents at a series of temperatures. (After Bramley and Lord.)

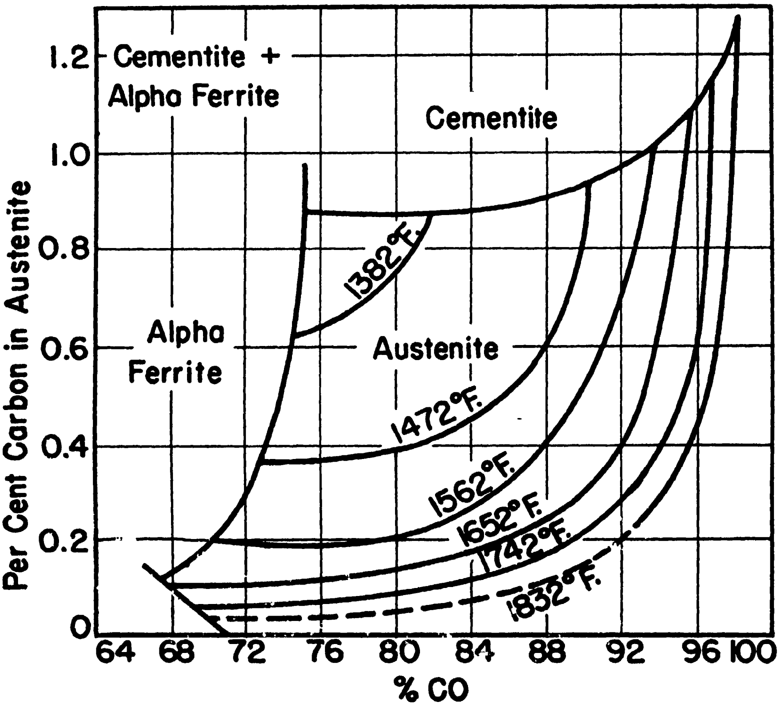

Fig. 2. Takahashi's isotherms for varying percentage of carbon monoxide and carbon dioxide in equilibrium with varying percentage of carbon in austenite.

Fig. 3 represents Takahashi's data (1926) in another manner. In this case the lines are for constant composition of the gas phase at the total pressure of one atmosphere. This method is also limited to a single total pressure per figure.

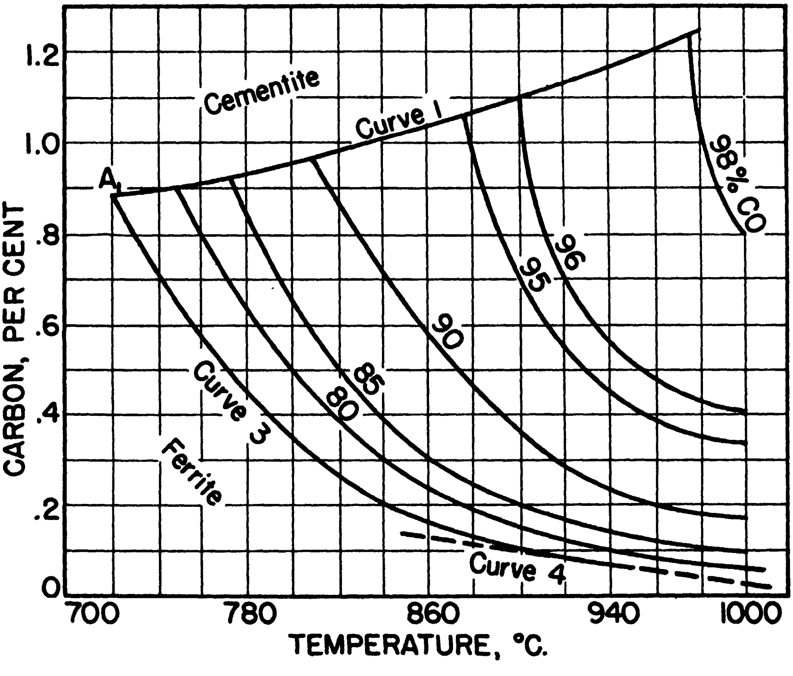

Fig. 3. Lines of constant gas composition in equilibrium with austenite (Takahashi).

Schenck (1926) has represented equilibrium in the CO-CO_2 Steel system at a total pressure of one atmosphere by the curves for constant composition of the austenite phase shown in Fig. 4. Johansson and von Seth (1926) have represented the equilibrium at a CO+CO_2 pressure of 0.4 atmosphere in a similar manner as shown in Fig. 5. This pressure of .4 atmosphere represents closely the pressure of CO+CO_2 that would be formed in air by reacting with an excess of carbon. Neither of these systems of curves represents the system sufficiently for general treatment.

Austin and Day (1940) have calculated values of the equilibrium constant (K′) for the reaction under consideration using the data of Becker (1930). Their graphical representation of these values of K′ on a logarithmic scale against temperature on a linear scale is shown in Fig. 6. K′ here is taken as equal to p^2_{CO} / p_{CO_2} which represents, referring to relation (2) above, only a part of the true equilibrium constant for the reaction. The activities of the iron and cementite are only indirectly taken into account in calculating these equilibrium constants. The curves in the figure represent variations of the values of this equilibrium constant with temperature for a number of carbon concentrations in the solid state. This figure is complete in itself for practical use since any partial pressure values of the reacting gases can be employed in its interpretation. This is a decided advantage over

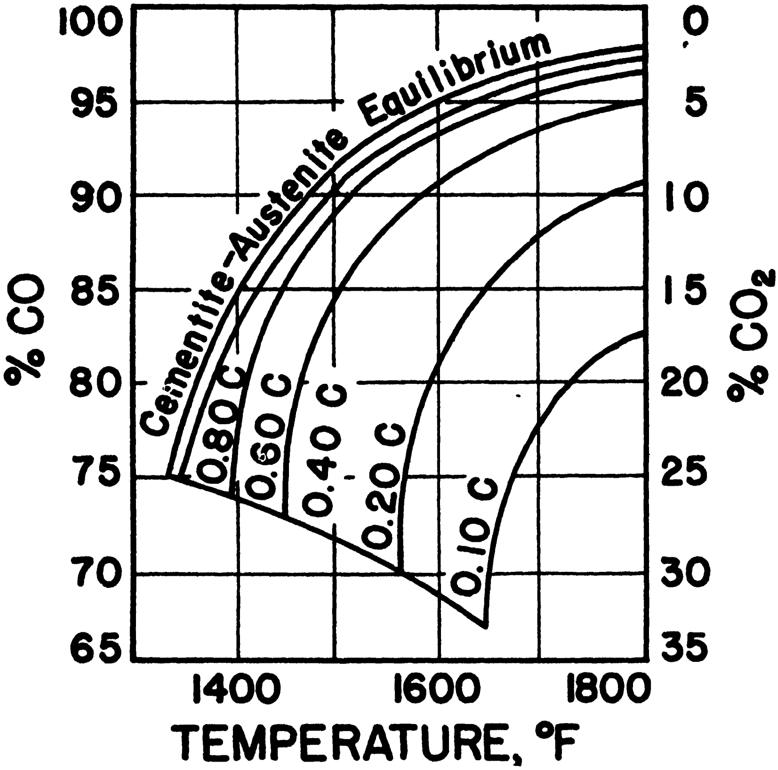

Fig. 4. Sohenck's curves for equilibrium of mixtures of carbon monmonhide and carbon dioxide with steels of different carbon content.

the other graphical method reported above where only one total pressure applied in each case.

In this report an attempt is made to take into account the activities of the iron and the iron carbide in calculating the true equilibrium constant as given in relation (2). The activities of the carbon monoxide and of the carbon dioxide are adequately represented by their partial pressures in the same manner as used by Austin and Day. The equilibrium constant is then written as

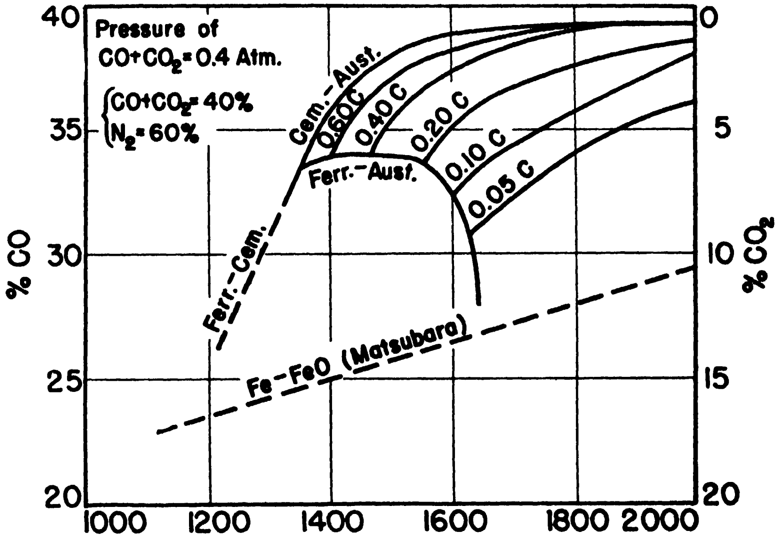

Fig. 5. Johansson-Von Seth curves for equilibrium of mixtures of carbon monoxide and carbon dioxide with steels of different carbon content. These curves were determined experimentally using 60 per cent nitrogen as a dilvent.

$$(3)\quad K = \frac{A^3_{Fe}}{A_{Fe_3C}} \qquad \frac{P^2_{CO}}{P_{CO_2}}$$

Over the temperature range being considered iron carbide is dissolved in gamma iron giving the solid solution austenite. Under these conditions neither the iron nor its carbide can be assumed to have unit activity when only one unsaturated solid phase exists. On the basis of general considerations we can assume that the activity of the iron is equal to, or proportional to, its mol-fraction (N_{Fe}) in the solid solution and that the activity of the iron carbide in the solid solution is proportional to its mol-fraction N_{Fe_3C}.

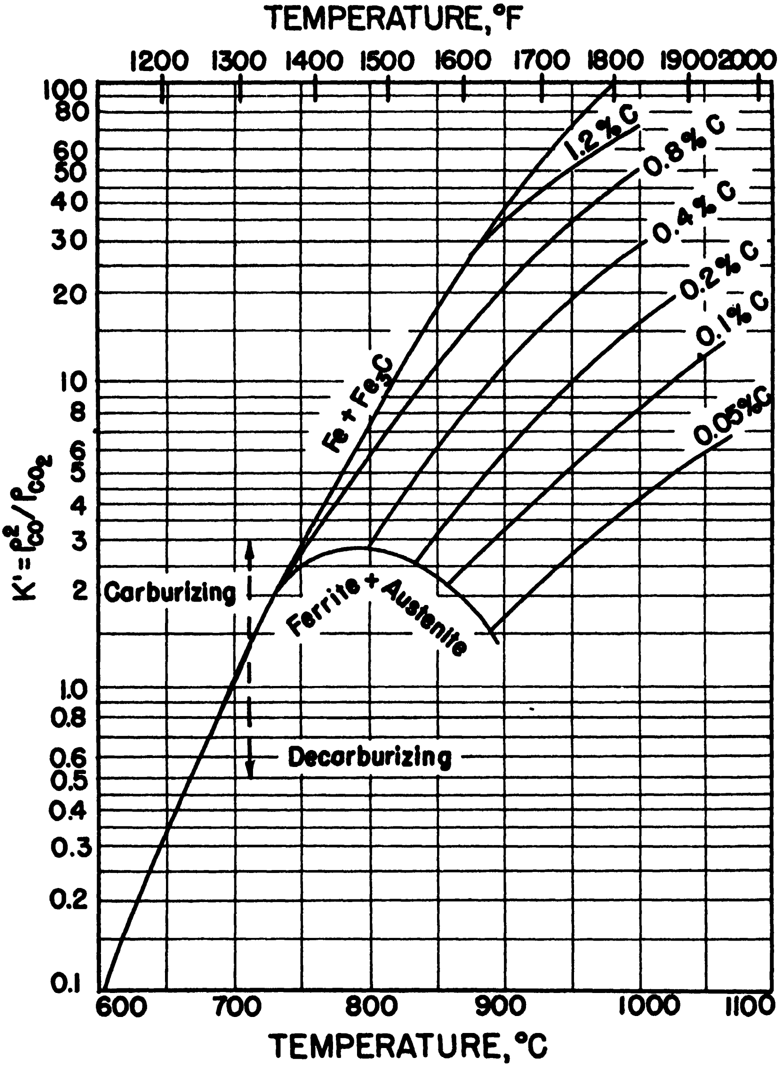

Fig. 6. Values of K′ against temperature. (Austin and Day).

The equilibrium constant for representing equation 1 can then be written

$$(4) \quad K = \frac{N^3_{Fe} \qquad P^2_{CO}}{N_{Fe_3C} \qquad P_{CO_2}}$$

Fig. 7 shows the relation between N^3_{Fe} / N_{Fe_3C} and the per cent carbon in a steel. This curve is made up from calculated values and is for convenience in calculations involving equilibrium constants. The data of Bramley and Lord (1932) have been used in evaluating equilibrium constants by equation (4). Their data are fairly complete for equilibrium gas compositions obtained with nine different steels at eight temperatures and under eight different total pressures of the reactive gases.

The calculated values of the equilibrium constants for these steels over the temperature range and at a total pressure of one atmosphere are assembled in table I. The table is divided into three sections according to the phases present in the steel at

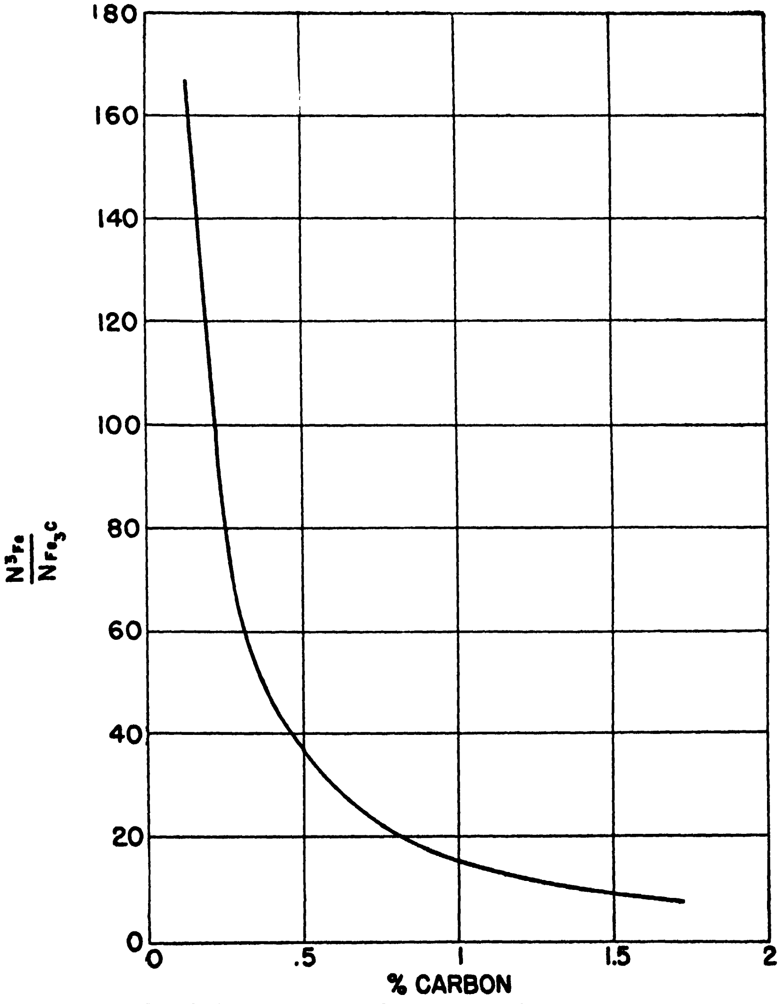

Fig. 7. Graph for couversion of per cent carbon in austentite of value of N^3_{Fe}/N_{Fe_3C}.

TABLE I
Equilibrium Constants Calculated from Data for One Atmosphere

%C C° Temp.	.125	.210	.260	.385	.500	.795	1.120	1.550	2.050	Av. K
750	....	69.4	....	....	..	93.9	....	103.7	...	93.9
800	156.	141	180	280	221	207	215	217	225	233
850	431	...	483	463	429	392	379	420	446	426
900	890	863	833	858	797	761	792	851	883	814
950	1540	1430	1390	1380	1310	1400	1230	1560	1240	1380
1000	2420	2510	2650	2400	2100	2620	1930	1520	2170	2200
1050	3690	4970	3290	3650	...	..	....	2460	....	3140
1100	5230	....	4690	...	4650	5050	...	....	....	4950

temperature. In the upper left section austenite and ferrite are in equilibrium and here the calculation of K is based on the percentage of carbon in the austenite phase and not on the percentage of carbon in the total solid. Likewise, the values in the area to the right are based on austenite composition and not on the whole solid state which is made up of austenite and free cementite. The composition of the austenite was in each of these cases estimated from the iron-carbon phase diagram. The large central portion represents the unsaturated austenite and only one solid phase. It can be seen that the value of K is practically constant for the different steels at one temperature. In the last column to the right are the average values of K for the different steels having only one phase at each of the temperatures; total pressure being one atmosphere. K values for the two-phase steels were not used in averaging because of the uncertainty of the austenite compositions.

Similar calculations have also been made to obtain corresponding average values of K for seven other total pressures, and all results are tabulated in table II. The values given for one atmosphere are the values taken from the last column of table I. Inspection of table II shows that the equilibrium constant as calculated by equation (4) is practically independent of total pressure. The last column in the table gives the overall average value of K for each temperature. Graphical representation of the relation between the equilibrium constants and temperature is presented in Fig. 8.

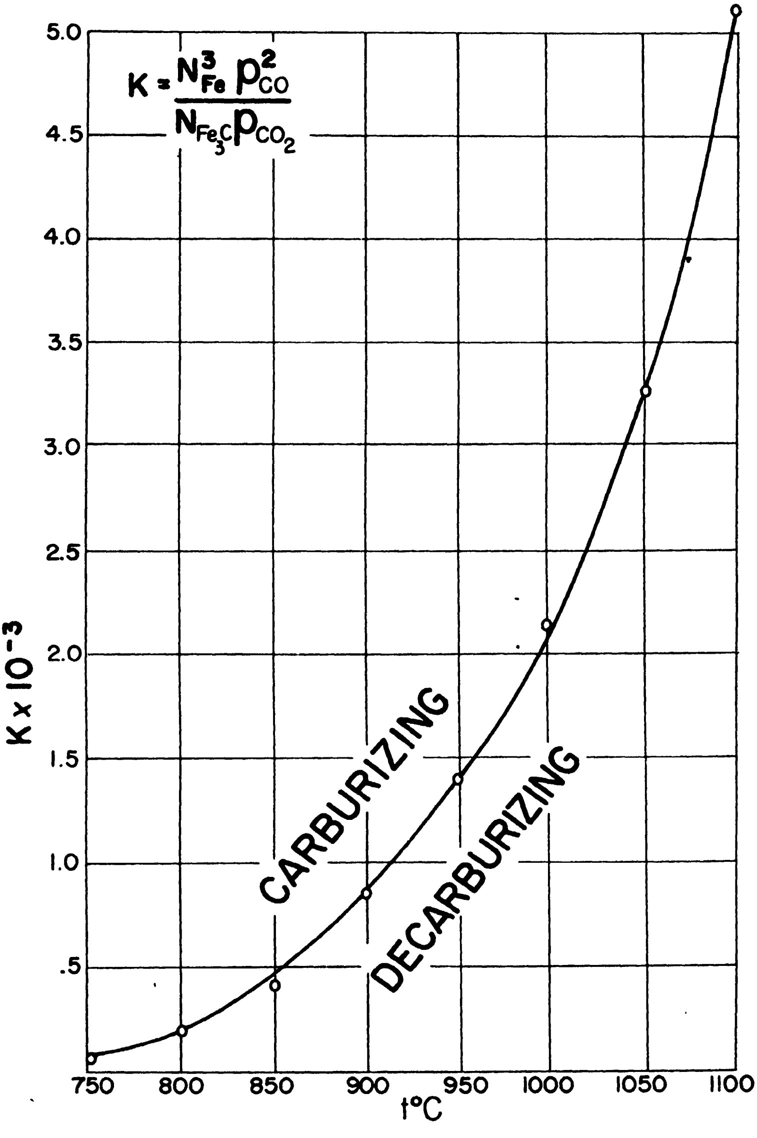
$K = \frac{N_{Fe}^3 p_{CO}^2}{N_{Fe_3C} p_{CO_2}}$
K x 10⁻³
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
750
800
850
900
950
1000
1050
1100
t°C
CARBURIZING
DECARBURIZING

TABLE II

Average Equilibrium Constants for Eight Total Pressures

Press. atm. / °C. Temp.	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	Overall Av. K
750°	92.0	103.	101.	93.9	101.	92.6	101.	91.7	97.1
800°	227	236	233	233	236	234	234	227	233
850°	418	426	431	426	406	409	420	400	416
900°	860	836	829	814	817	779	775	771	811
950°	1280	1400	1370	1380	1340	1370	1330	1260	1340
1000°	----	2110	2260	2200	2100	2160	2040	2060	2130
1050°	----	3300	3250	3440	3140	3280	3300	3150	3270
1100°	----	5880	5000	4950	5180	4780	4880	5120	5090

At any temperature, there will be a tendency for the steel to carburize if the mass-action expression for the reaction under the conditions imposed gives a value greater than the mass-action expression for the reaction at equilibrium. That is, conditions that give values above the curve in Fig. 8 are carburizing; furthermore, conditions that give values below the curve are decarburizing to the steel. Suppose, for example, that a steel containing 0.8 per cent carbon is to be annealed at 800°C. and a gas neutral to the steel is desired. Assume that the total active gas pressure is to be 0.34 atmospheres. In Fig. 8 the value of the equilibrium constant at 800°C. is 233, and the value of N^{3}_{Fe}/N_{Fe_3C} for an 0.8 per cent carbon steel is 21.9 in Fig. 7. The value of $P^{2}_{CO}/P_{CO_2}=233/21.9 =10.6$. In addition, $P_{CO_2}=0.34—P_{CO}$. Therefore $P^{2}_{CO}/0.34—P_{CO} =10.6$. Solving for Pco gives a value of 0.3297 atmosphere pre-

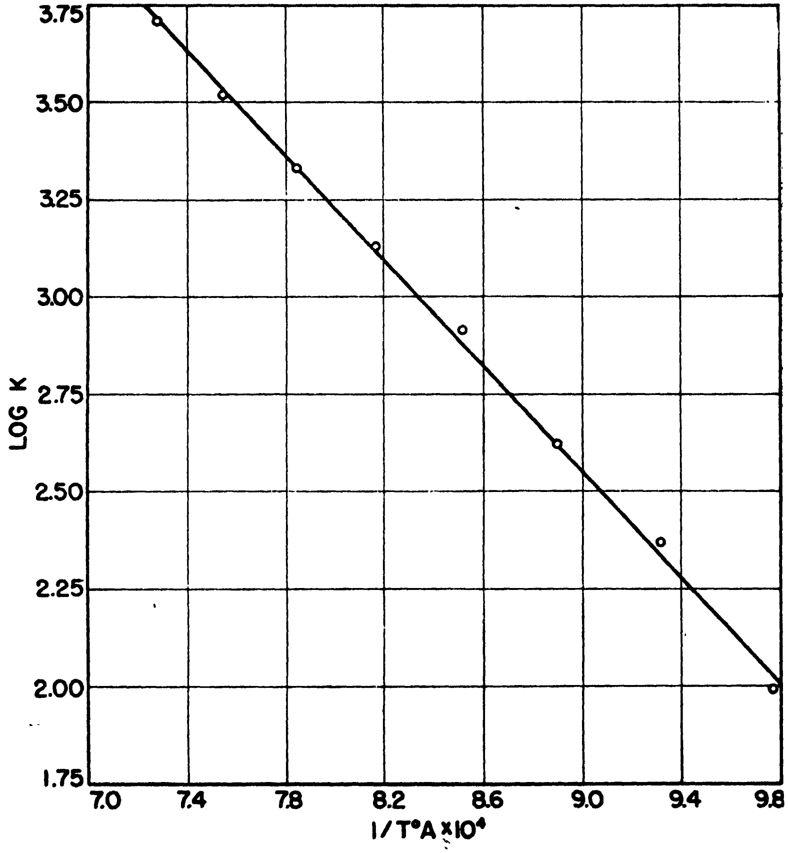

Fig. 9. Values of Log K against 1/T°A.

sure of the CO and 0.0103 atmospheres pressure of CO_2 in the gas to anneal the 0.8 per cent carbon steel at 800° C. without carburizing or decarburizinz it.

The equilibrium constants calculated above can be used for the determination of thermodynamic properties in connection with equation (1). Fig. 9 shows a plot of log K against $1/T°A$ and all points fall close to the straight line. Calculation of $\triangle H$ for reaction (1) from the slope of this line gives a value of about 30,000 calories which is in close agreement with values obtained by other methods of calculation for the same reaction in which the Fe_3C is in solid solution in gamma-iron.

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QUALITATIVE MICROANALYSIS OF NON-FERROUS METALS

GEORGE W. BROWN AND LOTHROP SMITH

During summer vacations, part of my school expense was earned as a purchaser of non-ferrous scrap metal for a small Chicago smelter. In such purchasing, it is very necessary to know something of the general composition of the metal. For example, in buying soldered articles, it is of vital importance to know whether the solder is high in tin or lead, and whether it contains antimony or bismuth. Other purchasers to whom I have talked have reported the same difficulty.

It is common practice in the purchase of metal from large smelters, to take the vendor's word for the composition, as the only alternatives are either an expensive analysis by a commercial laboratory, or the establishment of a laboratory by the small foundry. Such a laboratory is ordinarily of limited use, and the expense is too high for practical justification.

An example of such a problem is one encountered by the firm of Christensen and Olsen of Chicago, who contracted to make small cast gears out of an alloy called 85-5-5-5, which is composed of Cu, Sn, Pb and Zn. The initial orders of castings proved satisfactory, but a subsequent large order was rejected because it was found that lead had accumulated in small globules throughout the castings making them very difficult to machine. The large smelter which furnished the metal for that order disclaimed responsibility, but analysis by a commercial laboratory showed the presence of a small amount of aluminum in the alloy, which would have the effect of causing the lead to segregate. The cost of the delay and rejection to the small foundry was several hundred dollars, and a series of such incidents could easily endanger profitable operation.

Such trouble can be avoided by qualitative analysis, provided that the expense of equipment and upkeep is not prohibitive. With this end in view, an attempt was made to apply the methods of qualitative microanalysis to some of the problems involved in the purchase of scrap.

Limiting the applications to non-ferrous alloys simplified the procedure in that fusions are not involved, and that a uniform method of solution with aqua regia could be specified. Such simplifications are of particular advantage where it is necessary to employ an analyst with a rather low level of technical training.

APPARATUS AND REAGENTS

Only twelve pieces of apparatus are needed for an analysis of the average metal sample. These are listed in Table I. The centrifuge is the only piece costing over $1.50. For extreme portability, the centrifuge may be eliminated, but it was found to be a great convenience and is preferably included.

Fifty-one reagents are needed, and while some are fairly expensive, large amounts are not necessary, and one set of reagents should last for a considerable time. These reagents are shown in Table II.

Tests were selected for 22 elements commonly found in nonferrous alloys. Each test was tried upon one or more alloys containing the element to be identified, and the most conclusive test adopted for inclusion in the outlined procedure. One of the critical points lies in the avoidance of contamination, and it is therefore recommended that stock bottles be used as the main source of reagent. The small portions of reagent used for each determination may then be discarded to avoid possibility of contamination.

TABLE I

LIST OF APPARATUS

Spot plate
Centrifuge
Centrifuge cones
Micro pipets
Gutzeit apparatus
Heavy filter paper
Eye droppers
Small vials for reagents
Black spot plate
Micro porcelain crucible
Micro burner or alcohol lamp
Casserole

TABLE II

LIST OF REAGENTS

1. Acetic acid (2N)
2. Alkali stannate reagent (Dissolve 5 g. of stannous chloride in 5 cc. of concentrated HCl. Dilute with water to 100 cc. When ready to use, mix with an equal volume of 25% (8N) NaOH solution.)
3. Alpha-nitroso-beta-naphthol (Dissolve 2 g. of alpha-nitroso-beta-naphthol in 100 cc. of glacial acetic acid and dilute with 100 cc. of water.)
4. Alizarin (0.01% solution, 0.6N in acetic acid and 3N in sodium acetate.) (Make up fresh)
5. Aluminon reagent (0.1 g. of aurin tricarboxylic acid is mixed with 50

cc. of water and enough concentrated ammonia added to make 100 cc. of solution.)

6. Ammonia (Concentrated)
7. Ammonium carbonate (5N)
8. Ammonium chloride (Saturated solution)
9. Ammonium molybdate (Add 35 cc. of nitric acid (Sp. gr. 1.2) to 100 cc. of a 5% solution of ammonium molybdate.)
10. Ammonium mercuric thiocyanate (9 g. of ammonium thiocyanate and 8 g. of mercuric chloride are dissolved in 100 cc. of water.)
11. Ammonium phosphate (5N)
12. Ammonium sulphide (Concentrated) (Make up fresh by bubbling hydrogen sulphide through concentrated ammonia.)
13. Antipyrine (Solid)
14. Antipyrine-thiocyanate reagent (Add solid antipyrine to 2N potassium thiocyanate reagent.)
15. Benzidine (Dissolve 0.05 g. of benzidine in 10 cc. of glacial acetic acid. Dilute to 100 cc. with water.)
16. Bromine water
17. Cuprous chloride solution
18. Dimethylglyoxime (1% alcoholic solution)
19. Diphenyl-carbazide (1% alcoholic solution) (Make up fresh)
20. Diphenyl-carbazide thiocyanate (To a saturated solution (alcoholic) of diphenyl carbazide, add potassium thiocyanate crystals to saturation.)
21. Dithizon (Diphenyl thiocarbazone) (0.002% in carbon tetrachloride.)
22. Hydrochloric acid (Concentrated) (6N) (0.1N)
23. Hydrogen peroxide (3%)
24. Iodine in 1N KI solution
25. Lead chloride (Saturated solution)
26. Magnesium metal (Powdered)
27. Nitric acid (Concentrated) (6N)
28. Oxalic acid (2N)
29. Para-dimethyl-amino-benzal rhodanine (0.03% in acetone)
30. Phenol (Solid)
31. Phophomolybdic acid (5%)
32. Phosphoric acid (Concentrated)
33. Potassium chromate (1N)
34. Potassium cyanide (5% solution)
35. Potassium hydroxide (1N)
36. Potassium iodide (1N)
37. Potassium thiocyanate (Solid) (2N solution)
38. Quinalizarin (Dilute solution in 0.1N NaOH)
39. Silver nitrate (Solid)
40. Sodium acetate (Solid) (Saturated solution)
41. Sodium carbonate (Saturated solution)
42. Sodium hydroxide (8N) (6N) (2N) (0.1N)
43. Sodium phosphate (2N)
44. Sodium tartrate (Saturated solution)
45. Sodium thiosulphate (Solid) (1N solution)
46. Stannous chloride (Solid) (1N solution in concentrated HCl)

47. Sulphuric acid (Concentrated) (6N)
48. Tartaric acid (Solid) (Concentrated solution)
49. Thiourea (10% solution)
50. Zinc metal (Powdered)
51. Zinc sulphate (2N)

PROCEDURES

In all cases the metal to be analyzed is treated in a centrifuge cone with aqua regia. If there is a residue, filter and treat the precipitate with concentrated HCl. (Test the HCl soluble portion for Al.) If a residue still remains, filter and treat the precipitate with concentrated ammonia water. A black or grey precipitate indicates the presence of Hg, but the test for Hg should be carried out also. To the filtrate, add dilute nitric acid. A white precipitate indicates the presence of silver.

Aluminum

Add one drop of the aluminon reagent to three drops of the unknown solution. Add an excess of ammonium carbonate solution. If a pink color persists, Al is present. A blank should be run for comparison. Be interferes with this procedure, and if present, the following alternate procedure should be used.

To two drops of the acid unknown, add ammonia until just alkaline plus one drop in excess. Add 3 drops of alizarin solution. A red or pink coloration indicates the presence of Al.

Antimony

Two drops of the aqua regia solution are heated to boiling on a watch glass and a few crystals of sodium thiosulphate are added. If Sb is present, there is a brown or red precipitate. With a blank there is a yellow precipitate.

Arsenic

Place a small piece of the unknown metal in the gutzeit apparatus, add a few grains of Zn and a little dilute sulphuric acid. Place a loose plug of cotton saturated with cuprous chloride in the body of the tube, and a piece of filter paper with a crystal of silver nitrate on it over the mouth of the apparatus. A brown coloration of the crystal indicates the presence of As. A blank should be run for comparison.

Beryllium

Make two drops of the solution to be tested alkaline with 6N NaOH, then slightly acid with dilute HCl. To one drop of this solution on the spot plate, add one drop of O.1N NaOH. Then test with one drop of quinalizarin. If Be is present there is a light blue color. A blank gives a purple color.

Chromium

Mix one drop of the unknown solution with one drop of bromine water on the spot plate. Add one drop of 6N NaOH and a crystal of phenol. Then add a drop of diphenyl-carbazide and a drop of concentrated sulphuric acid. There is a deep violet coloration in the presence of Cr. Mo and V interference, can be inhibited with oxalic acid.

Bismuth

Place one drop of the aqua regia solution on a spot plate, add one drop of lead chloride solution, 1 drop of 2N NaOH and 1 drop of KCN solution. Add two drops of alkali stannate reagent, and mix by stirring. A distinct brown color will be obtained within three minutes if Bi is present.

Cadmium

Mix on the spot plate 1 drop of freshly prepared diphenyl-carbazide thiocyanate with one drop of solution and 1 drop of ammonia. A violet coloration indicates the presence of Cd. Co interferes.

Cobalt

Take, in a watch glass or centrifuge cone, 1 drop of solution, 1 drop of ammonium chloride, 2 drops of ammonia, and 2 drops of water. Filter. To 2 drops of the filtrate, add 2 drops of phosphoric acid, 1 drop of potassium iodide and 2 drops of sodium thiosulphate. Filter. To 2 drops of this filtrate add one drop of alpha-nitroso-beta-naphthol and one drop of HCl. A brown coloration indicates the presence of Co. The last portion of this test should be carried out on a spot plate.

Copper

Make solution alkaline with 6N NaOH, then just acid with dilute nitric acid. Add one drop of the acid solution to one drop of ammonium phosphate, 1 drop of zinc sulphate, and 1 drop of ammonium mercuric thiocyanate in a casserole and warm. A positive test is indicated by a violet color. Co and Ni interfere.

Gold

Mix one drop of solution, 1 drop of stannous chloride, and one drop of KCNS, and boil in water. A purple color indicates the presence of Au. Hg interferes.

Iron

One drop of solution, 1 drop of KCNS, and 1 drop of O.1N HCl are mixed on a spot plate. A deep brown on red precipitate indicates the presence of Fe.

Lead

One drop of solution, 3 drops of potassium cyanide, 1 drop of ammonium chloride, and one drop of dithizon are mixed on a spot plate. A pink coloration indicates lead. A blank should be run for comparison. (The reagent should be a deep green color and should not be over two months old.)

Magnesium

One drop of solution and 2 drops of KOH are mixed on the spot plate. Add enough of a solution of iodine in 1N KI to color the spot a dark brown. Then add KOH until the solution is yellow in color. If a dark brown precipitate persists, it is an indication of Mg. A blank should be run for comparison.

Manganese

A drop of the test solution is treated on filter paper with NaOH, then a drop of tartaric acid solution is placed in the middle of the moist spot, followed by benzidine. A blue color indicates Mn.

Mercury

One drop of solution and four drops of sodium phosphate are mixed in a centrifuge cone. Filter. One drop of the filtrate and one drop of a saturated solution of Para-dimethyl-amino-benzal rhodanine in alcohol are mixed on the spot plate and solid sodium acetate added. A red color appears in the presence of Hg.

Molybdenum

Make slightly alkaline with NaOH and filter off any precipitate which forms. Put one drop of concentrated HCl, one drop of KCNS, one drop of stannous chloride and one drop of the unknown on the spot plate. A deepening of the red color indicates the presence of Mo. A blank should be run for comparison.

Nickel

Use a spot plate. Mix 1 drop of solution with 1 drop of 3% hydrogen peroxide, 1 drop of saturated sodium tartrate solution, 2 drops of saturated sodium carbonate solution and one drop of alcoholic dimethylglyoxime. A red precipitate indicates the presence of Ni. A red coloration alone is not an indication of Ni.

Phosphorus

Make the solution slightly alkaline with NaOH, then slightly acid with dilute HCl. Use one drop of this solution on the spot plate with 2 drops of ammonium molybdate, 1 drop of benzidine and 3-6 drops of sodium acetate. Stir well after the addition of sodium acetate. A blue color indicates the presence of P.

Silver

Make solution alkaline with NaOH, then acid with dilute HCl. Take 2 drops of this solution with 2 drops of ammonium carbonate and centrifuge. On the spot plate take two drops of the filtrate; add one drop of potassium chromate and one drop of acetic acid. Let stand for one minute. A red coloration or precipitate indicates the presence of Ag.

Tin

Take three drops of the aqua regia solution on a spot plate and add a few grains of solid tartaric acid. Then add ammonia until the solution is alkaline. Take one drop of this solution on the spot plate and add one drop of freshly prepared ammonium sulphide reagent. Absorb the excess liquid; add one drop of HCl and a few grains of powdered Mg. Take one drop of this solution, and add one drop of phosphomolybdic acid. A blue color indicates the presence of Sn. The above test for Sn is specific even in the presence of Sb.

Vanadium

Two drops of the aqua regia solution are mixed with one drop of concentrated sulphuric acid and one drop of hydrogen peroxide on a spot plate. A pale pink to brown color indicates that V is present. A blank should be run for comparison.

Zinc

Place a drop of the solution on a watch glass, and heat with NaOH. Filter. Acidify the filtrate with acetic acid. Filter if a precipitate forms and treat three drops of the filtrate on a black spot plate with 2-5 drops of anti-pyrine-thiocyanate reagent. A white precipitate indicates the presence of Zn.

In many cases I found that the micro procedures were definitely superior to the type of procedure usually followed and being limited to non-ferrous alloys, many short cuts could be used. An example is the test for tin. Usually, if antimony is present in the same alloy as tin there is trouble and interference. The usual method of testing an alloy of this sort is to evaporate with nitric acid, treat the residue with sodium hydroxide to make alkaline and then add potassium sulphide solution. This is then heated on a water bath for some time and diluted and acidified with hydrochloric acid to precipitate the tin and antimony as sulphides. Next the precipitate is freed from sulfur. Then the tin and antimony sulphides are heated with concentrated hydrochloric acid, diluted, heated and saturated with hydrogen sulphide. The precipitate is then finally tested for antimony and the solution for tin, if through this involved procedure you haven't forgotten what you were looking for. As a contrast to this procedure, I found the following micro procedure for tin which works even in the presence of antimony. The metal is put into solution in aqua regia on the spot plate, treated with tartaric acid and then ammonia until alkaline. One drop of this solution and one drop of ammonium sulphide are mixed, one drop of hydrochloric acid and a few grains of magnesium are added. This solution then gives a blue color with phosphomolybdic acid if tin is present.

CONCLUSIONS

I believe that qualitative microanalysis is the answer to the problem for the small industrialist. The reagents and complete set of equipment take up very little space and may be stored in a corner to be used only as the need arises. Also it is not necessary to have advanced training in chemistry to be able to carry out the tests. It is simply a matter of following directions and watching for the proper colors. An afternoon of practice is probably all that is needed for a man to become a relatively skilled operator with microtechniques. In addition the procedure is rapid and inexpensive. The man in industry is always in a hurry and speed and economy are vital. In the example given of the Chicago foundry, the managers would have gladly given fifty dollars to solve their problem and also satisfy the customer immediately. For this amount of money they could have a complete set of micro-equipment and could solve not only that problem, but many similar to it.

The field buyer of metal could also carry equipment enough with him to analyze samples of goods that he intended to buy. Thus transactions would be speeded up and the buyer would feel free to offer what the metal was worth without discounting for the possibility of being cheated.

In short, I feel that micro-procedures in this limited field are definitely an asset and should be brought to the attention of the industrialist.

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REPORTS

VAPOR PRESSURE OF IODINE MONOCHLORIDE

JACOB CORNOG AND ELDON BAUER

The Pearce and Snow dynamic method of measuring vapor pressure has been adapted to the measurement of the vapor pressure of iodine monochloride in the solid and liquid phases. Heats of sublimation, vaporization and fusion were obtained by applica tion of the Clausius-Clapeyron equation.

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THE DIFFUSIONS COEFFICIENT OF HEMOGLOBIN IN PURE WATER SOLUTION.

F. E. KITE, DONALD A. KING AND W. G. EVERSOLE

Carbon monoxide hemoglobin prepared from beef blood by the method of Marshall and Welker (J. Am. Chem. Soc., 35, 820. 1913) was allowed to diffuse from a water solution of constant concentration into pure pater contained in a thin flat cell of optical glass.

The cell containing the diffusion column along with other cells of the same thickness containing appropriate standard solutions was illuminated at intervals by a beam of parallel light of wave lengths (5600-5700 A) corresponding to an absorption band of the solute. The transmitted light fell on an Eastman Spectrographic Plate, Type III-D.

Concentrations at different levels in the diffusion column were determined in terms of the standards from the photographic density of the negative. The diffusion coefficient was calculated from these data by the method used previously in this laboratory.

The diffusion coefficient was found to have a minimum value of 2.2 x 10^{-7}cm.^{2}/sec. at a concentration of 0.94 grams per 100 cc. of solution. The limiting value at infinite dilution was 4.2 x 10^{-7}. All solutions were salt-free and unbuffered, so that these values are not comparable with literature values.

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DISSOCIATION PRESSURES OF SOME POTASSIUM POLYHALIDES

JACOB CORNOG AND ELDON BAUER

Potassium dichloro iodide ($KLCL_2$ or KCL-ICL, m. p. 195°) and potassium trichloro di-iodide (KCL.2ICL, m. p. 45°) have been prepared and their dissociation pressures measured.

Both of these are new compounds. The potassium dichloro iodide (m. p. 60°) described by Wells and Wheeler (also by Ephraim) has been found to have the formula $KLCL_2.H_2O$.

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IOWA CITY, IOWA

A MEASUREMENT OF THE MAGNITUDE OF THE ELECTROKINETIC CURRENT IN LIQUID FLOW THROUGH A SINGLE CAPILLARY.

W. G. EVERSOLE AND W. W. BOARDMAN

The potential difference, E, between the two ends of a capillary, through which a steady flow of liquid was maintained, was measured by means of unpolarizable electrodes connected to a potentiometer circuit, and at the same time shunted through a known resistance, R. The value of R was varied from 1 to 98000 megohms. For each value of R there was a corresponding value of E, and a current, I (=E/R), through the resistance. The electrokinetic current, I_e, was obtained by extrapolating the plot of E/R versus R to the limit R=O.

The value of the electrokinetic potential, ζ, can be calculated from I_e by means of the Helmholtz-Smoluchowski equation,

$$\zeta = \frac{4\ \eta\ 1}{r^2 D P} \qquad I_e ,$$

without the use of conductivity data.

The specific surface conductivity can also be evaluated from the same data if the specific conductivity of the liquid in bulk is known.

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SOME INSOLUBLE RESIDUE CORRELATIONS OF MISSOURI AND VIRGIL STRATA IN IOWA

E. H. WENBERG

Iowa geologists have long experienced great difficulty in isolating good key beds in the younger Pennsylvanian strata. This difficulty is due to the cyclothemic nature (see fig. 2) of the sediments. The marked success of the Missouri Geological Survey in distinguishing southward extensions of these strata in Missouri on the basis of their insoluble residues has led to a similar attempt in Iowa.

Spot and channel samples were gathered from surface exposures and from mines. (See fig. 1). Although these samples tended to have weathered characteristics unless they were collected with great care, they were better than well samples in that they were uncontaminated from material above and they were more truly representative of the rock unit sampled. In the laboratory the rocks were crushed and sieved to a uniform size and digested with dilute cold hydrochloric acid. By subsidation the coarse residue portion was separated from the fine residue and was subsequently studied under a binocular microscope for mineral and fossil content. The fine residue was described only on the basis of color. In order to show the relationships of the residues to one another

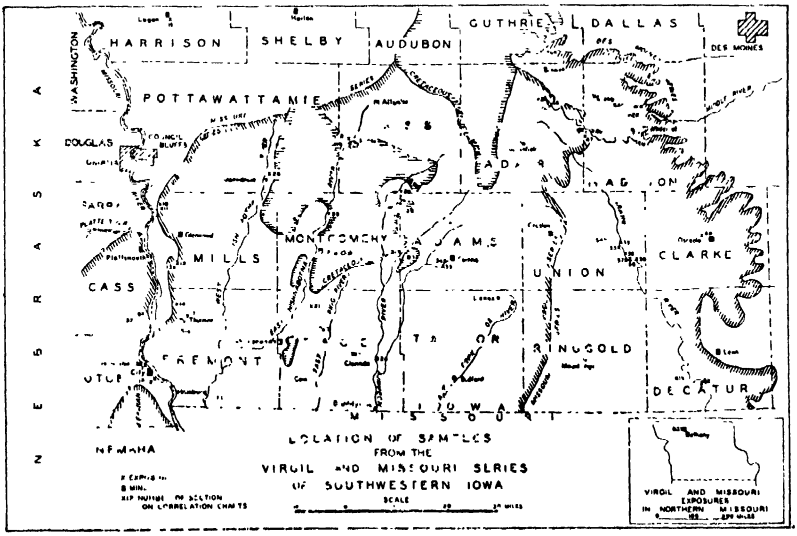

FIG. 1. Location of samples collected.

use was made of graphs or logs in which the ordinates represent the thickness of the strata sampled, the abscissae reveal the percentage by weight of the coarse residue, the fine residue, and the soluble material, and the patterns represent the types of residue present.

An examination of the residue logs (figures 3 to 12) and a reference to the map showing the origin of the samples (fig. 2) leads to the following conclusions. Both the percentage of residue and the type of residue are quite similar in nearby exposures of the same rocks; but with an increase in distance between exposures there is a corresponding decrease in similarity between either type or percentage of residue.

One of the best examples of long distance insoluble residue correlations is that of the Grandhaven limestone in the upper part of the Wabaunsee group. Lithologically the Grandhaven resembles other Wabaunsee limestones, but in four out of four samples examined minute dark gray tourmaline crystals were found. This is remarkable because tourmaline crystals are quite rare in these strata.

Both the Nyman and the Nodaway coals are good horizon markers and are easily recognized in the residues in Iowa. However, in Nebraska both coals thin out and disappear toward the west.

The Elmont limestone is frequently confused with the Reading. As a general rule the residues of the Elmont consist of foraminifera and gray clay. In contrast the residues of the Reading contain large amounts of glauconite and of brown clay. Glauconite is not found in the Elmont. The presence of glauconite in the residues of a building stone widely quarried in the Tarkio River valley has led to the correlation of that stone with the Reading limestone exposed in the Missouri River valley. However, the underlying Wakarusa limestone, also, contains glauconite and may be correlated with at least some of the Tarkio valley limestones.

The Soldier Creek is mostly sandstone and is easily recognized even in the field.

Frequently the Nodaway coal and the overlying Howard limestone contain pyrite replacements of fossils and white gypsiferous internal molds of ostracodes.

Below the Severy shale are the massive limestones and well-developed cyclothems of the Shawnee group. Chert, especially the dark variety, is common in the Coal Creek limestone. The underlying Holt shale has a persistent black fissile phase and overlies a persistent thin limestone. The black chert and the underlying black fissile shale have led to the recognition of the Coal Creek limestone as far northeast as Adair county. In each cyclothem there is a black fissile shale overlying a thin limestone and overlain by a thick cherty limestone. The thick limestones frequently carry silicified foraminifera. The Sheldon limestone foraminifera are fragile and perforate whereas most of those found in the Curzen, the Ervine Creek, the Spring Branch, the Kereford, and the Plattsmouth are fusulinids. The Rakes Creek shale, although not well exposed, seems to be largely made up of sand and silt. Blocky, sandy shales are common in these cyclothems. The Shawnee group seems to have begun with shore or near shore deposits for red beds and sand are common in the Snyderville and the Weston.

Similar near shore deposits seem to have closed the period of Missouri deposition. They are represented by the maroon shales of the Vilas and the Bonner Springs formations. Beneath these red shales lie the well-developed cyclothems of the Missouri series. Four massive thick limestones,—the Argentine, the Drum, the Winterset, and the Bethany Falls,—are especially thick and persistent. Their close resemblance to one another has led to much miscorrelation. However, the residues differ slightly. The Argentine is quite cherty and contains few other residues. In all of the Drum limestone samples examined there were white spines; many of the spines are fragile hexactons and are beautifully preserved in the residues. The Winterset is cherty, often forms a fine brown residue, and in many cases contains bundles of hollow ferruginous spines. This latter residue found in the limestone exposed at Logan, Harrison county, strengthens the previous correlation of that limestone with the Winterset limestone in Madison county. The Bethany Falls is usually divided into three massive limestones by two thin shaly layers. In contrast to the fine brown residues of the Winterset limestone the Bethany Falls residues are generally gray. An interesting lateral variation in type of residues is afforded by the Middle Creek limestone. In Decatur and in southern Madison counties the Middle Creek is a nearly pure limestone of constant thinness. However, as it extends to the northeast part of Madison county there is a decided thickening and a large amount of sand is included.

As in the case of the Virgil series, the Missouri series is based on extensive sandstones and red beds.

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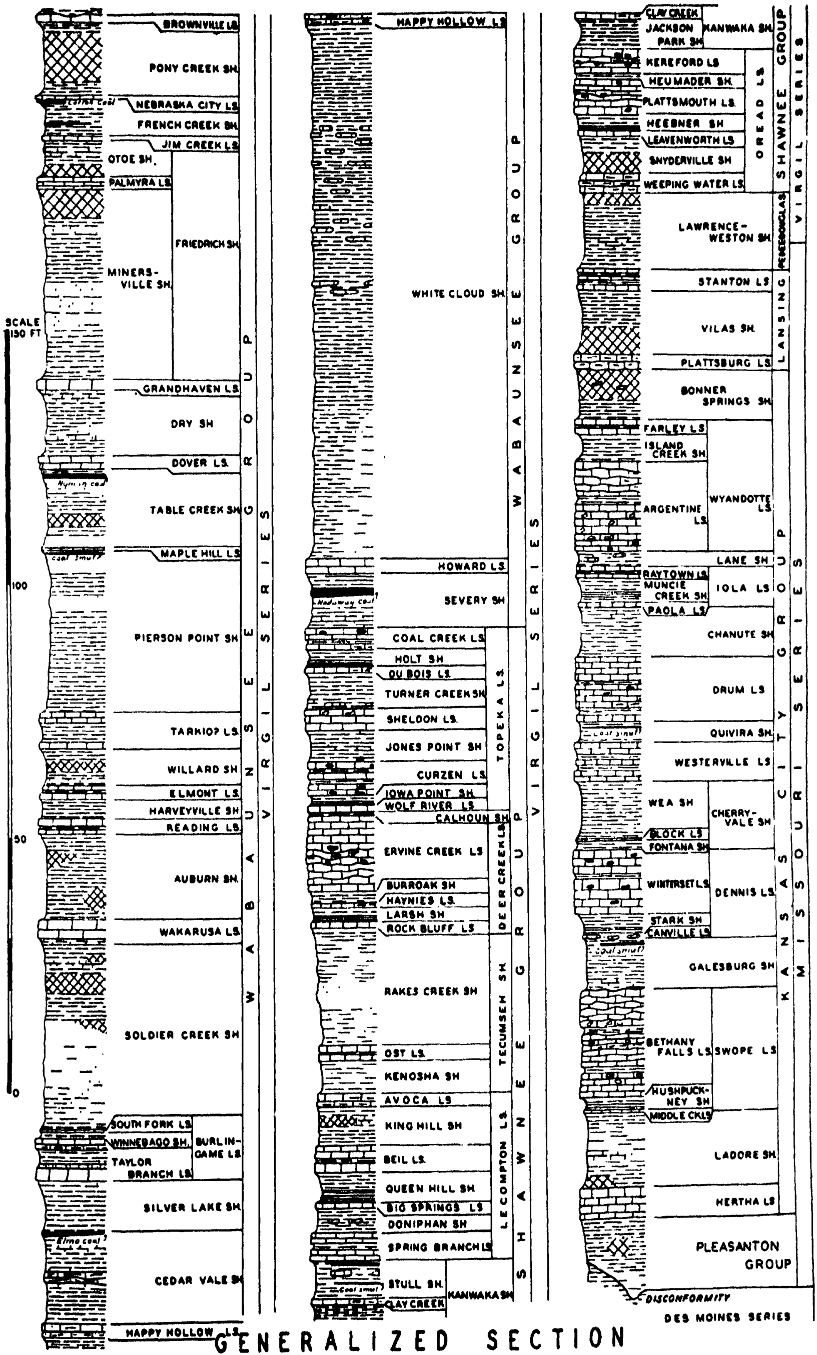

GENERALIZED SECTION OF THE VIRGIL AND MISSOURI SERIES IN IOWA

FIG. 2.

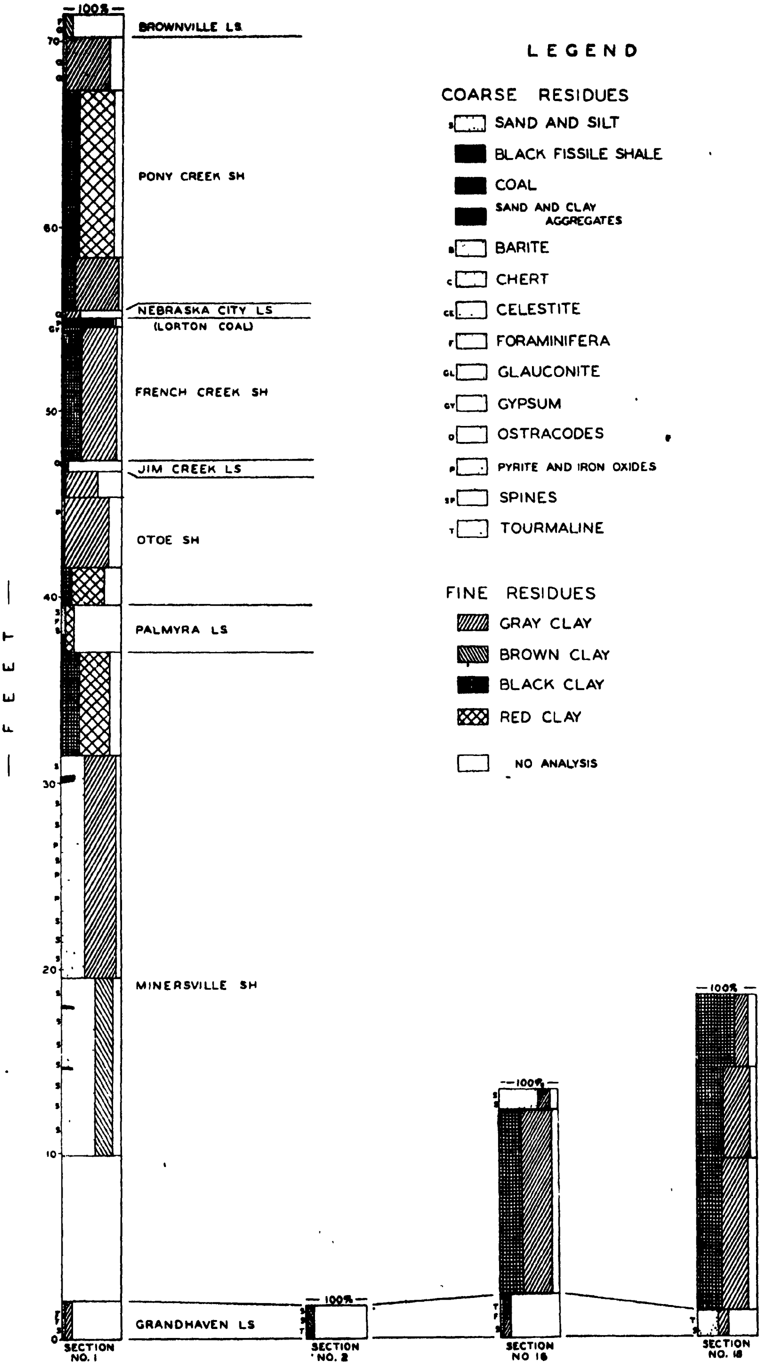

Fig. 8. Insoluble residue logs of Brownville limestone to Grandhaven limestone.

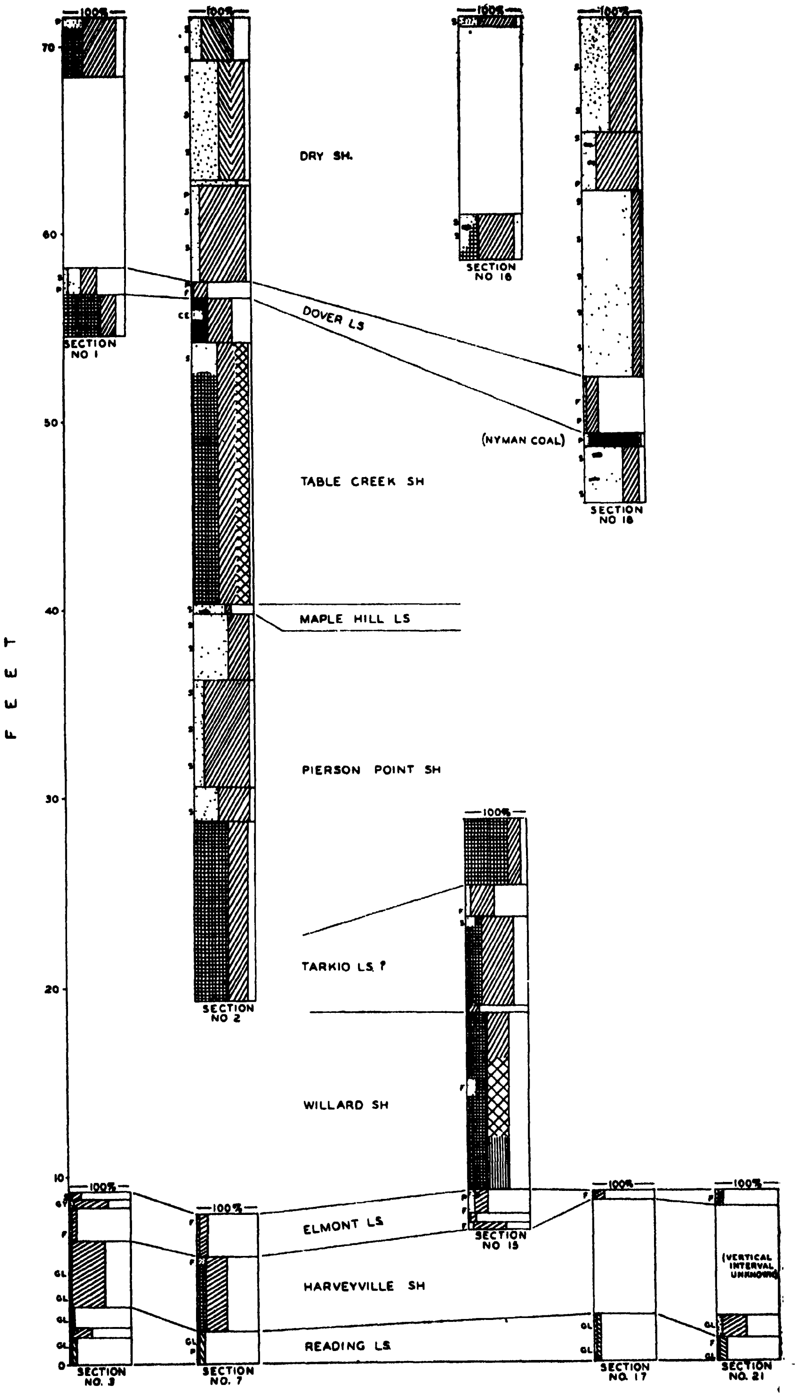

FIG. 4. Insoluble residue logs of Dry shale to Reading limestone.

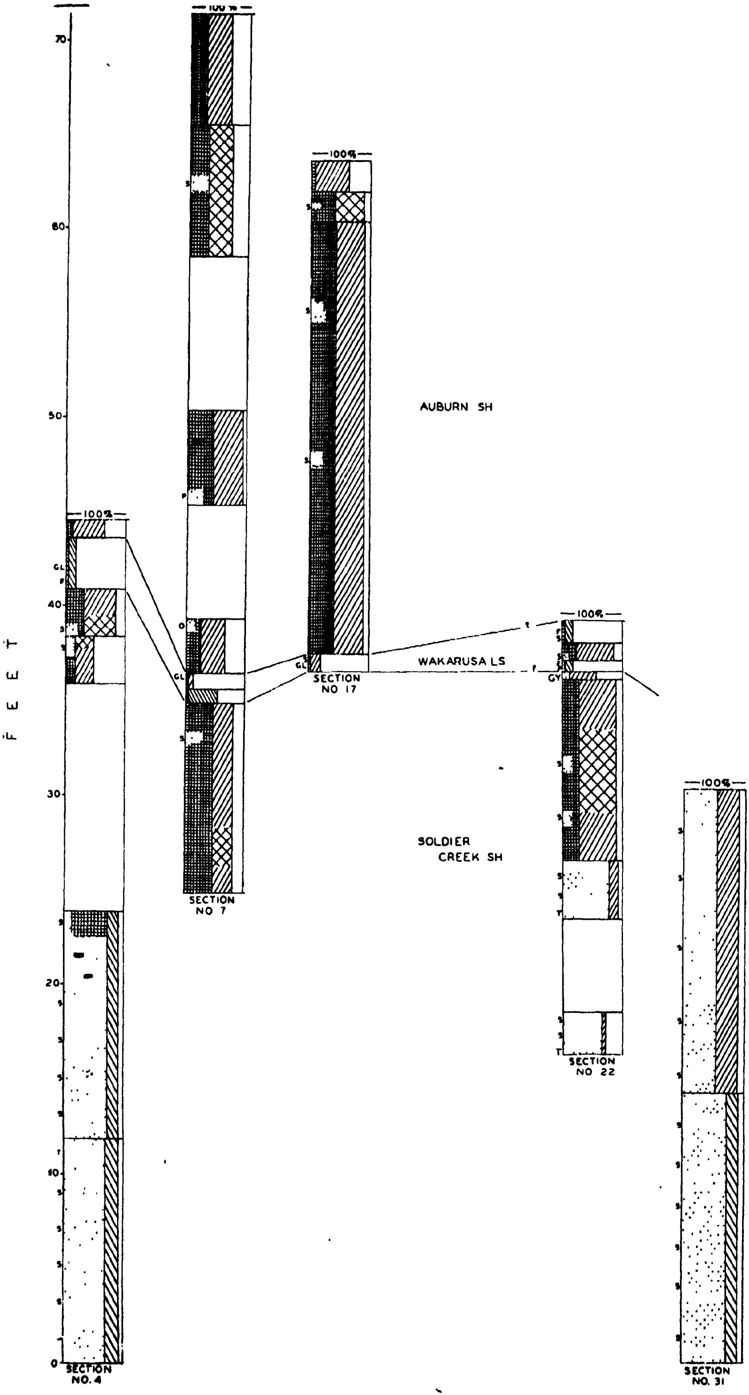

Fig. 5. Insoluble residue logs of Auburn shale to Soldier Creek shale.

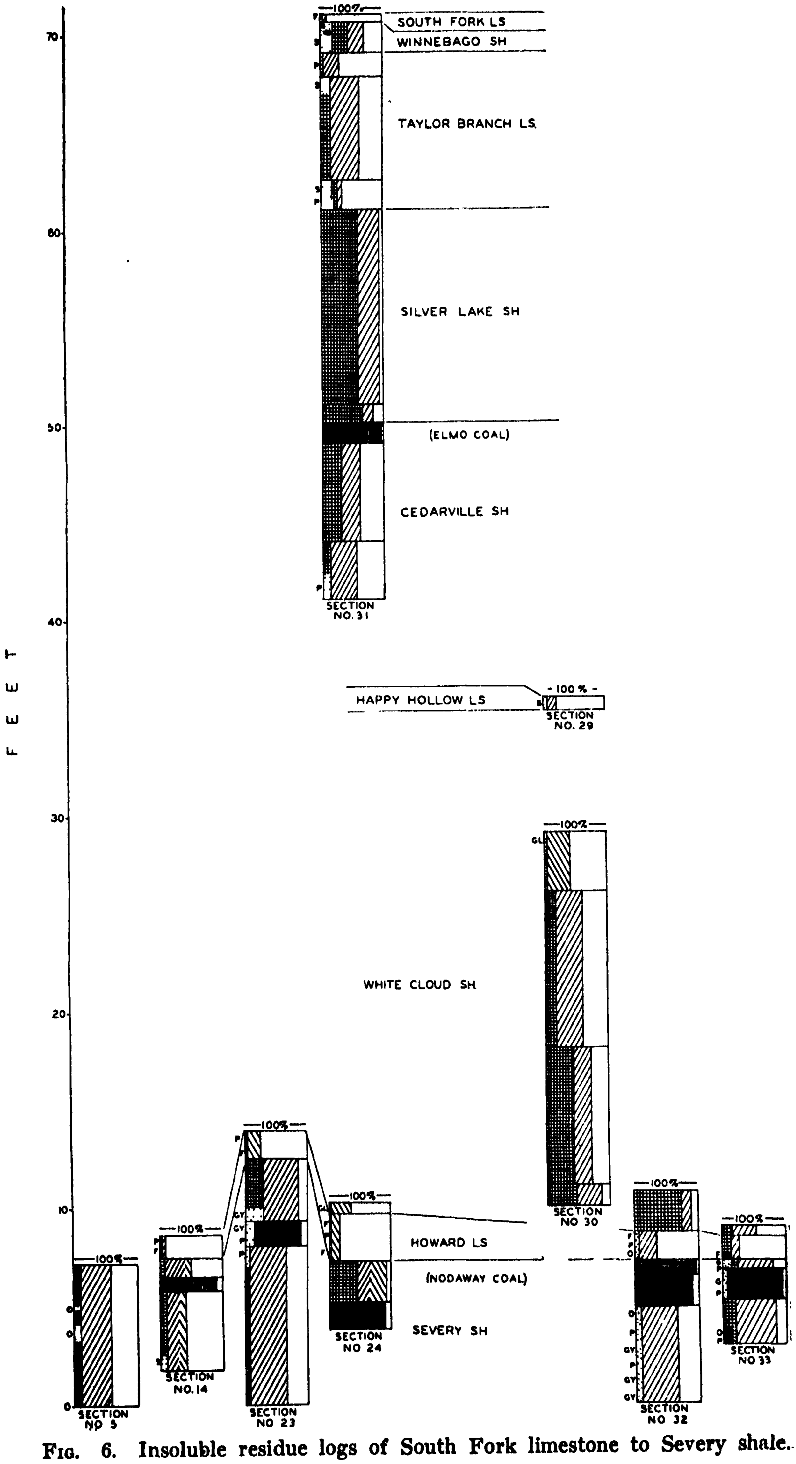

Fig. 6. Insoluble residue logs of South Fork limestone to Severy shale.

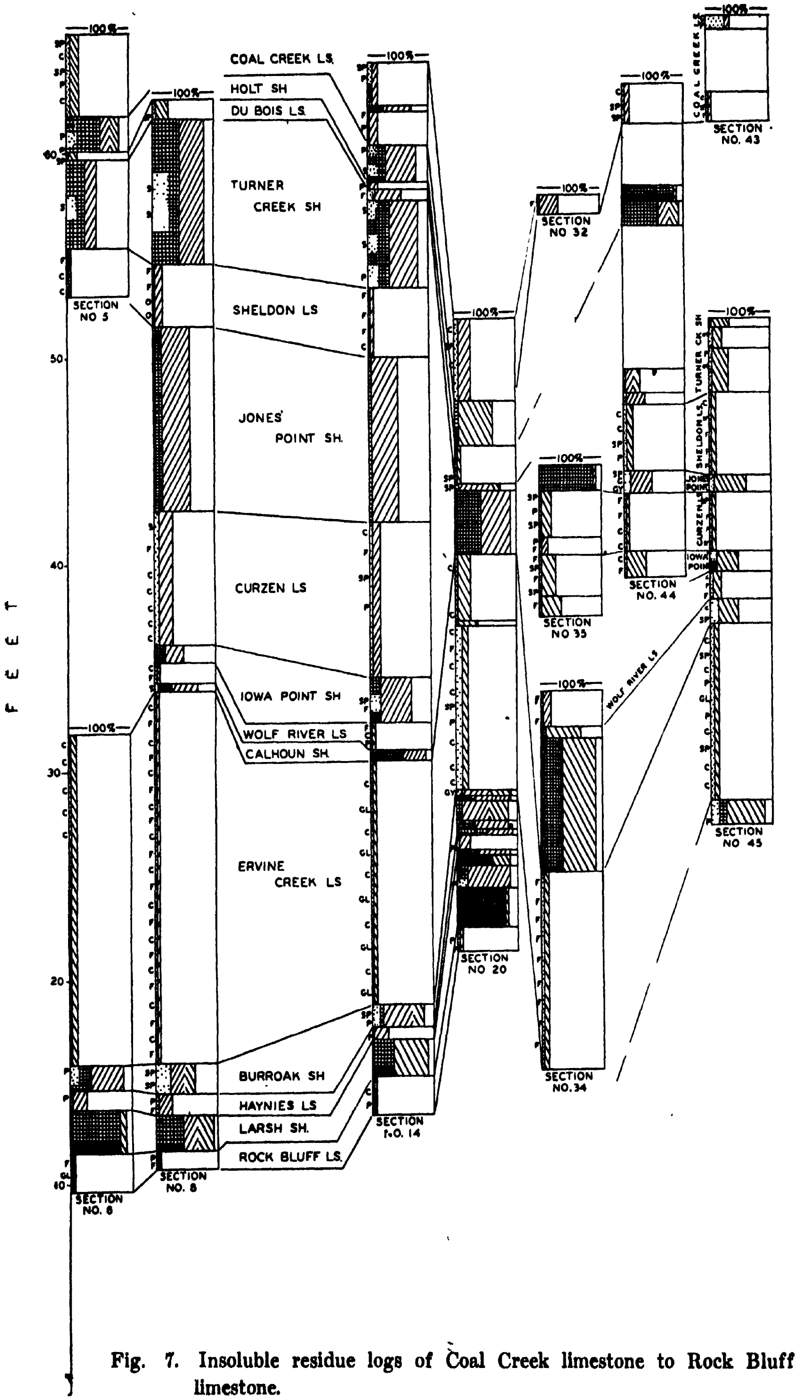

Fig. 7. Insoluble residue logs of Coal Creek limestone to Rock Bluff limestone.

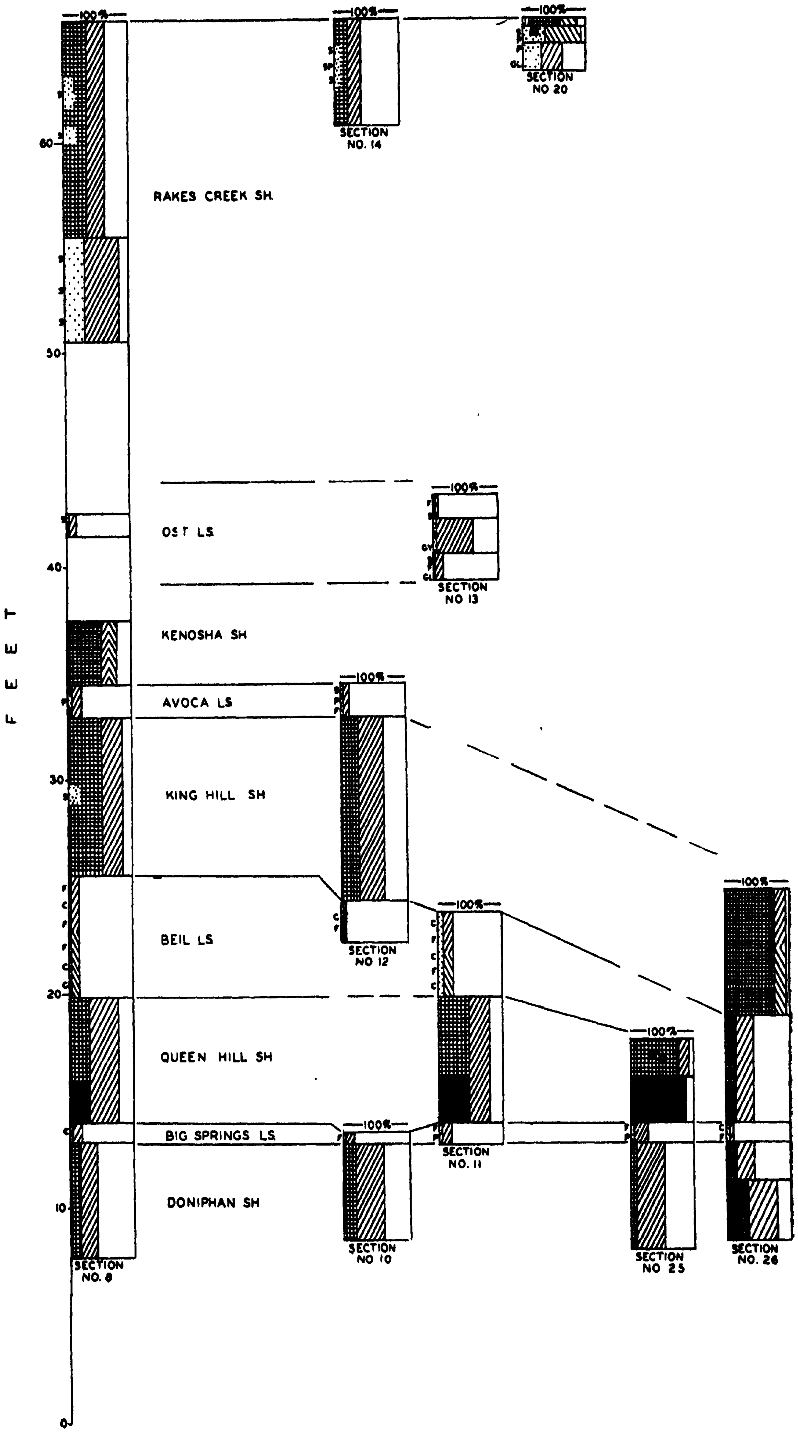

Fig. 8. Insoluble residue logs of Rakes Creek shale to Doniphan shale.

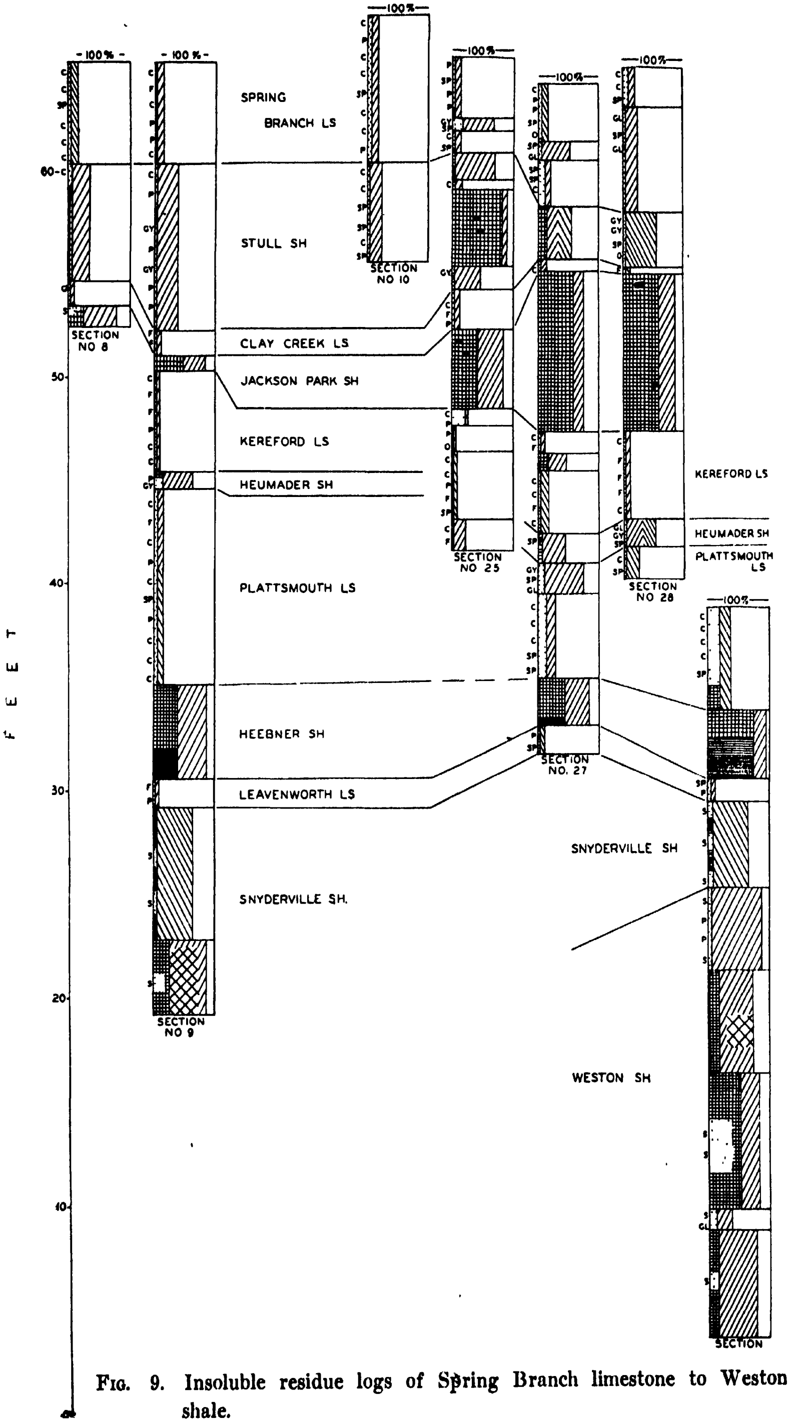

FIG. 9. Insoluble residue logs of Spring Branch limestone to Weston shale.

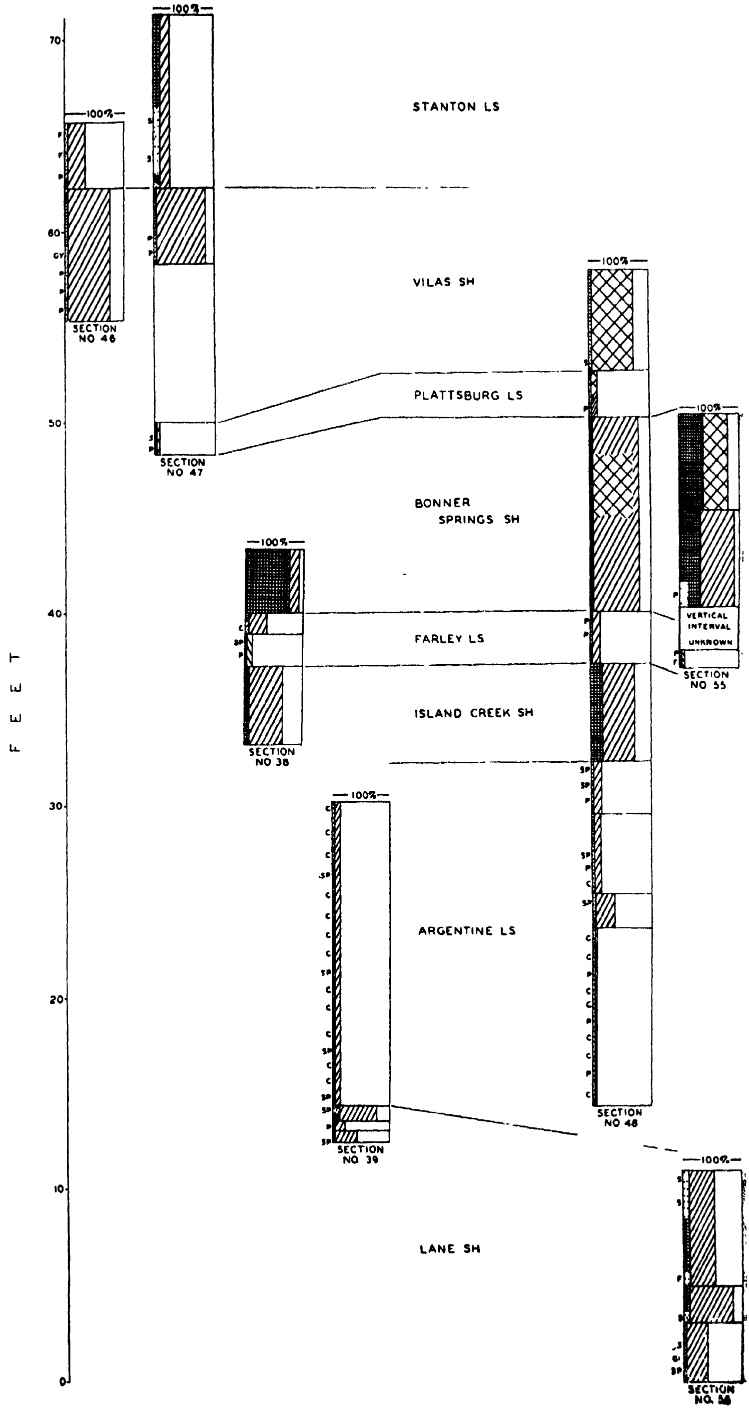

FIG. 10. Insoluble residue logs of Stanton limestone to Lane shale.

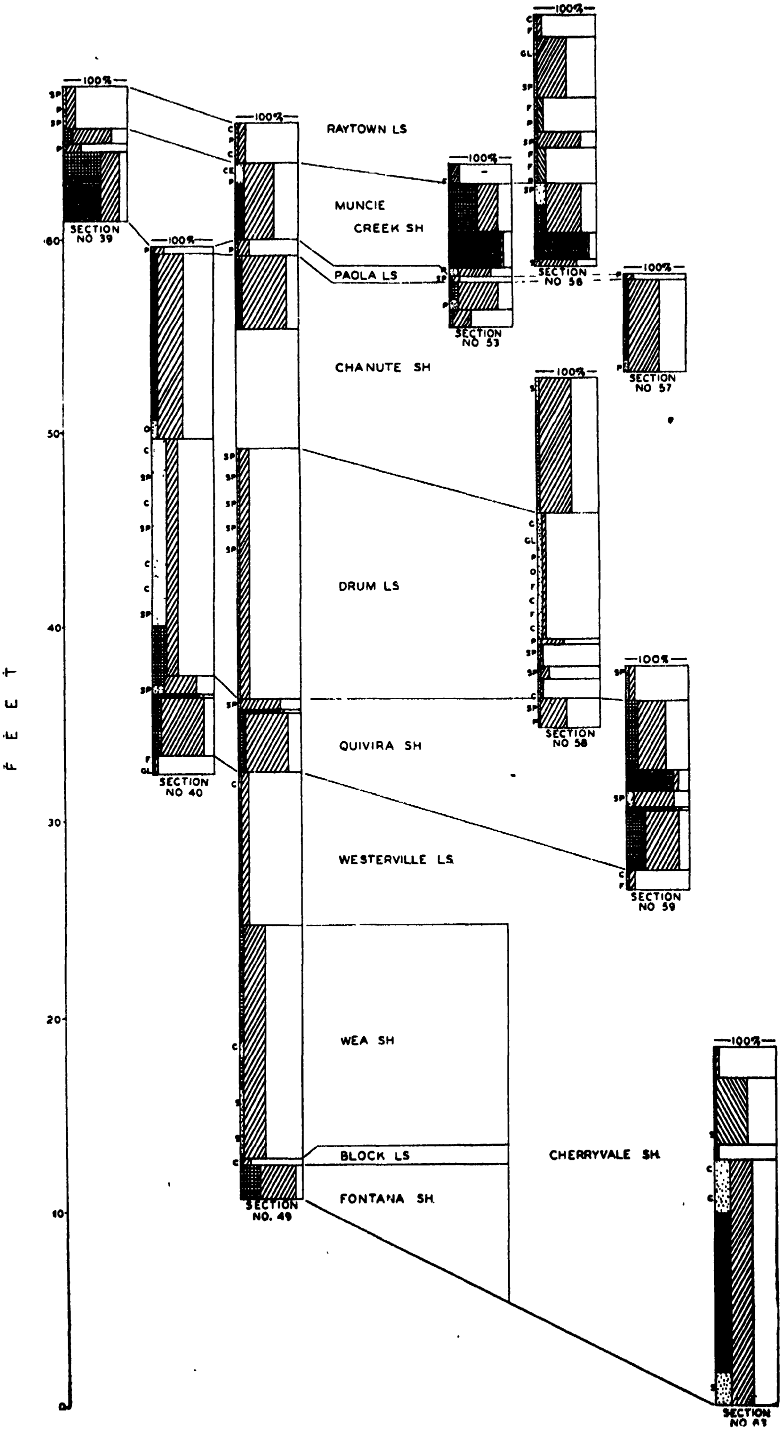

Fig. 11. Insoluble residue logs of Raytown limestone to Fontana shale.

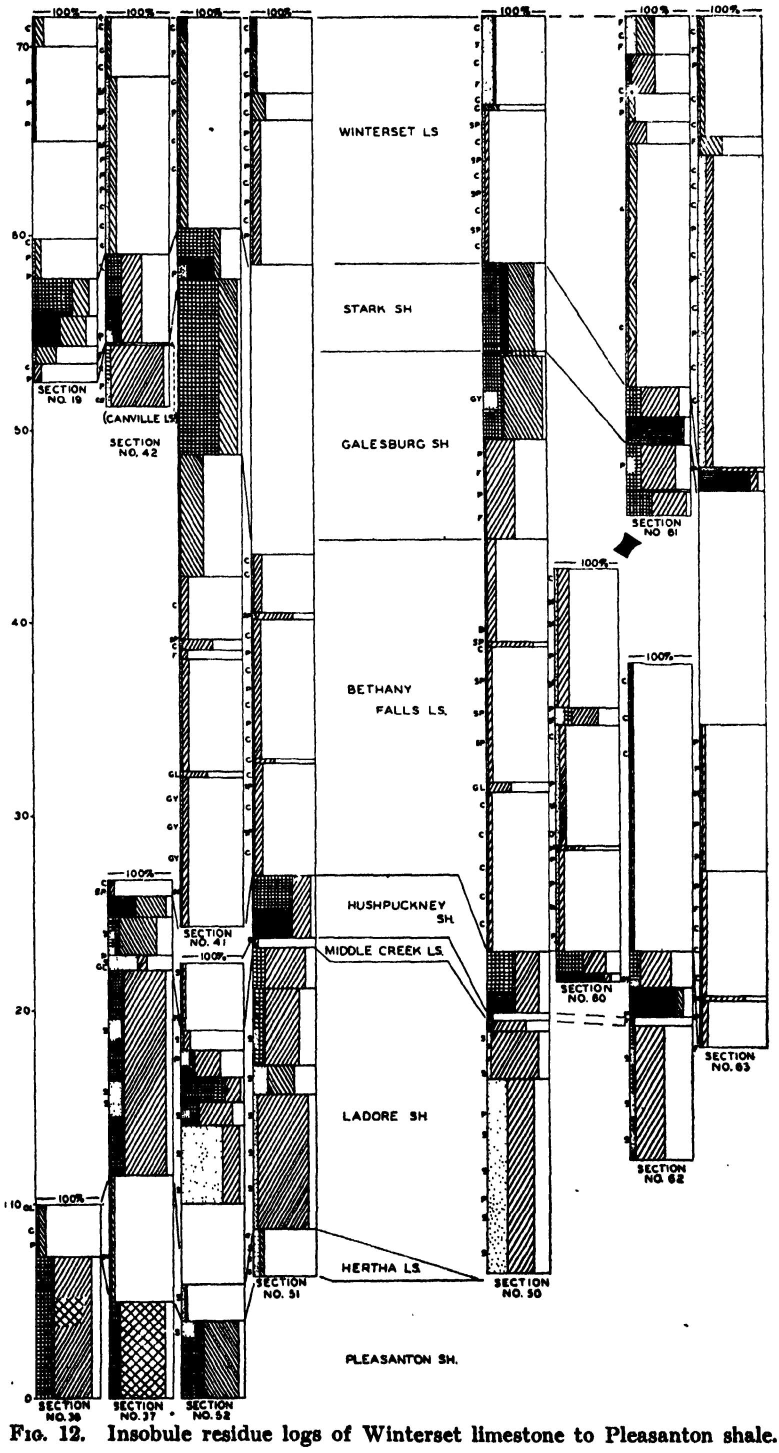

Fig. 12. Insobule residue logs of Winterset limestone to Pleasanton shale.

DID BEAVERS IMPOUND WATERS FOR AMES PEAT BOG?

CHARLES S. GWYNNE

INTRODUCTION

A deposit of peat located in a valley about a mile northeast of Ames, has been known for many years. It is rather unusual in that it lies along a small mature valley rather than in a swale of the upland. Investigation is believed to show that the deposit developed as the result of impounding of water by beaver dams.

DESCRIPTION

Location and topography: The deposit is located along two confluent valleys tributary to the Skunk River valley in the NW¼ of the NE¼ and the E½ of the NW¼ of Sec. 36, T. 84 N., R. 24 W., (Fig. 1).

The flat of the main valley (Fig. 2) has a width of approximately 150 feet where it merges with the Skunk River floodplain. It widens above to as much as 250 feet and then gradually narrows to 150 feet at its confluence with the tributary valley, three-eighths of a mile east. The flat of the tributary valley coming in from the north narrows upstream to a width of 100 feet at the end of the deposit. Beyond that it narrows further and gradually merges, within a short distance, with a weak drainage line of the upland. The valley flat is approximately 60 feet below the surrounding upland at the upper end of the peat deposit and 120 feet below it where it merges with the Skunk River floodplain. The valley sides slope gently at approximately 250 feet per mile. Other valleys tributary to the Skunk in this part of its course are similar to these described.

The flats of the valleys containing the peat deposits are generally smooth and with uniform slope except for certain exceptions to be noted. They are marked, however, by a deep trench which begins a few hundred feet above the lower end and continues almost the full length of the part of the valley occupied by the deposit. This has a maximum depth of nine feet in the middle of its course and decreases to six feet at the upper end. No other valley along this part of the Skunk River valley is marked by an incised channel of a depth comparable to the one described above.

As stated the valley flat has a generally uniform slope. Exceptions are found at three places, along the valley, at each of which there is a change in the slope noticeable to the eye (Fig. 3). Although the difference in gradient is small it is apparent that the profile of this part of the valley is one of sloping steps, each increasing somewhat in slope toward the upper end. Two of the breaks in slope are at narrow places in the tributary valley, one near the upper end and the other near the lower end. The third is a few hundred feet below the confluence with the tributary.

A circular mound fifteen feet in diameter rises approximately two feet above the surrounding flat (Fig. 4) near the lower end of the tributary valley. The upper part of this mound to a depth of a foot or more is a mixture of sand, clay, and organic material, but below that depth it is much more peaty. There is no nearby depression from which the material for this mound might have been excavated. A similar mound of more subdued character is found near the lower end of the main valley, on the north margin of the flat.

The remains of a man-made earthen dam rise a few feet above the valley flat near its point of confluence with the Skunk River floodplain. The presence of this and of the detritus which formed behind it has obviously changed and masked the earlier surface.

Description of peat. The deposit of peat as has been indicated lies along the course of these two valleys for a distance of approximately one-half mile. The width of the deposit has not been accurately determined but if it extends beneath the valley flat adjacent to the places where it is exposed in the incised channel, it is approximately 150 feet in width at the lower end and 100 feet at the upper end, where it merges with a small bog underlain by peat, and in which until recently, peat has been forming.

The peat and associated materials are exposed along the sides of the incised channel for much of the entire distance described, the peat to an average thickness of approximately eighteen inches and a maximum of three feet or more. The deposit ranges from pure peat to earthy material, clay, silt or sand. Much of it is typical peat, made up of plant detritus ranging from the finest fragments up to decayed branches and trunks a few inches in diameter. Snail shells are abundant. Many bison bones and also a few of deer have been found. Wood fragments bearing the marks of rodent teeth are also reported to have been found and reported to Mr. George Hendrickson of Ames.

The peat of the lower valley is underlain chiefly by clayey and silty material with only vague stratification. Some sand and fine gravel are present in a few places. The incised channel of the upper valley has cut through the alluvial deposits into the underlying glacial till to a depth of several feet in at least one place where the channel impinges on the side of the valley. The peat is practically at the surface over much of the area, elsewhere it is covered with a few or several inches of peaty soil. The latter is particularly the case in the lower part of the main valley, where the peat is also generally only a foot or so thick.

Headwater erosion of the incised channel has been very rapid over the past few or several years. The peat-forming bog has decreased in size until it is now only about 100 feet long whereas ten years ago it had a length of approximately 150 feet. The water-loving plants are slowly dying out as the bog continues to become better drained. Springs and seeps in the vicinity of the bog cause runoff in the channel during most years of normal runoff.

Adjacent valleys tributary to the Skunk River do not, so far as the writer has been able to discover, contain peat deposits.

Discussion

Origin of the peat. Deposits of peat can only have been formed in a body, large or small, of stagnant or nearly stagnant water. A shallow depression is necessary for the accumulation of such stagnant water. In this part of the world the depressions are commonly of two types of origin, either the result of glaciation or the fluvial processes operating on rather broad flood plains. Those of glacial origin are represented in northern Iowa by the depressions in the drift surface. Many of the larger of these depressions contain peat deposits formed since the Mankato stage of the Wisconsin glaciation. Others of smaller size contain soils with a higher content of organic matter.

The depressions formed by the fluxial processes are best represented by the ox-bow lakes formed by the cutting off of meanders. Depressions on flood plains may develop in other ways and they may range greatly in size. Those large enough to accumulate a deposit of peat could only develop on the flood plains and terraces of the larger streams.

This deposit which has been described is found along the course of a comparatively small valley, the valley flat of which is notable for its lack of irregularity except for the deeply incised channel. It has, however, a steep downstream slope. It is obvious that there must have been obstructions across the valley in order to provide the conditions necessary for the accumulation of this peat deposit. There is no possibility of landslides having provided such obstruction. The valley is too wide, it is of insufficient depth, and the drift material does not slide in a manner such as to completely block even a small valley for any length of time.

There are several features which point to beaver dams as the barriers behind which the swampy conditions developed.

(1) The presence of the peat along the valley with a difference in elevation of approximately 50 feet between the lower and upper ends. Accumulation in this fashion might well develop behind obstructions placed at points higher and higher up the valleys. It is difficult to see how it could have developed in any other way.

(2) The step-like gradient of the upper part of the flat suggests the earlier presence of beaver dams.

(3) The low mounds are strongly suggestive of beaver houses or dens.

(4) The fine alluvium underlying much of the peat is material such as would accumulate in a beaver pond in its earlier stages, while the water was still deep.

(5) Beavers are known to have been native to this part of the country when it was settled, and there seems no reason why they might not have occupied this valley, particularly since it may have been spring-fed.

Ruedemann and Schoonmaker (1938) have described broad and flat alluvial plains as much as nine miles in length in the Schuylerville, Cohoes and Troy quadrangles in New York. They are ascribed to deposition behind beaver dams.

Summary. The peat deposit covers a sloping valley floor for a distance of approximately one-half mile to a width of as much as 250 feet. The peat grades to clayey, silty and sandy material containing much organic matter, and is underlain by several feet of generally fine alluvium. All the evidence points toward the development of this peat in a basin or basins partially enclosed by beaver dams.

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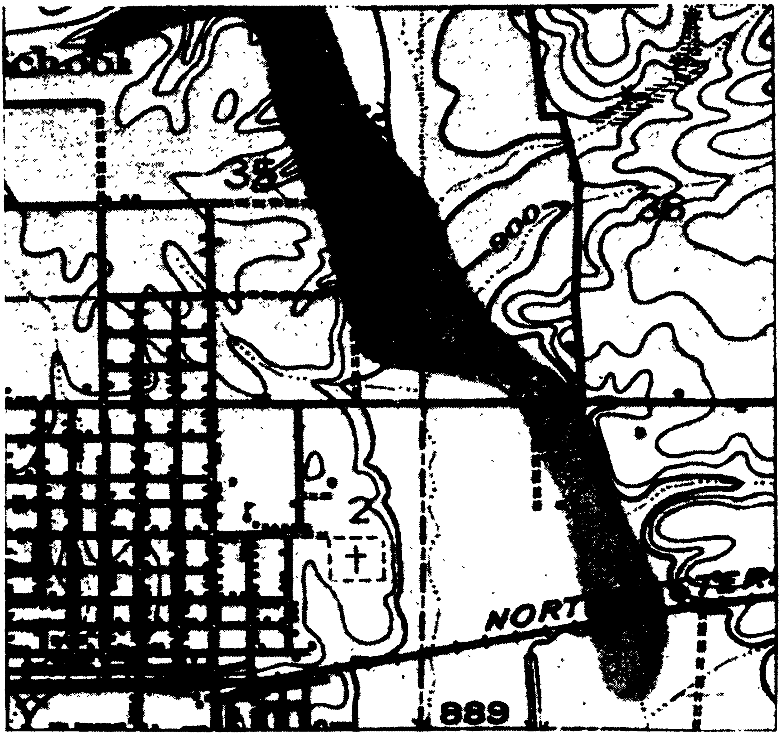

FIG. 1. Map showing location and features of peat deposit. Area of the deposit is shown by pattern of dashed lines, possible dams by heavy lines across the valley, possible beaver houses by crosses. Shaded area in Skunk River valley indicates forested area. Area is two miles square.

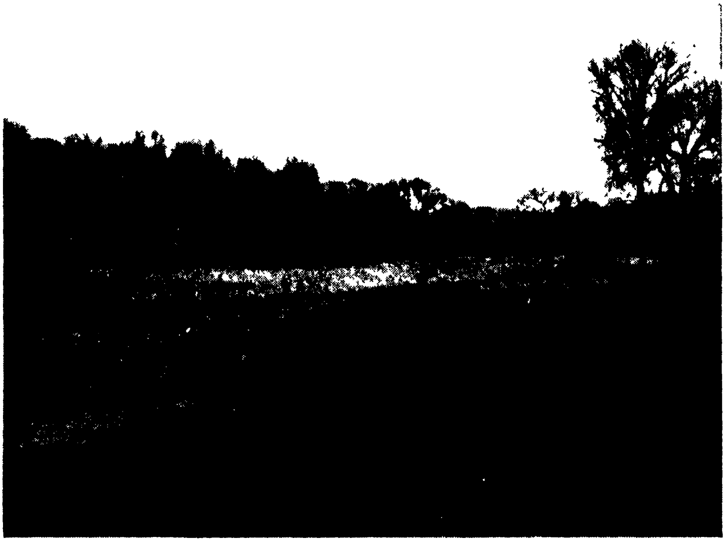

FIG. 2. View up the valley containing peat deposit. The lower end of the deposit is near the large trees at the right. Incised channel begins left of center.

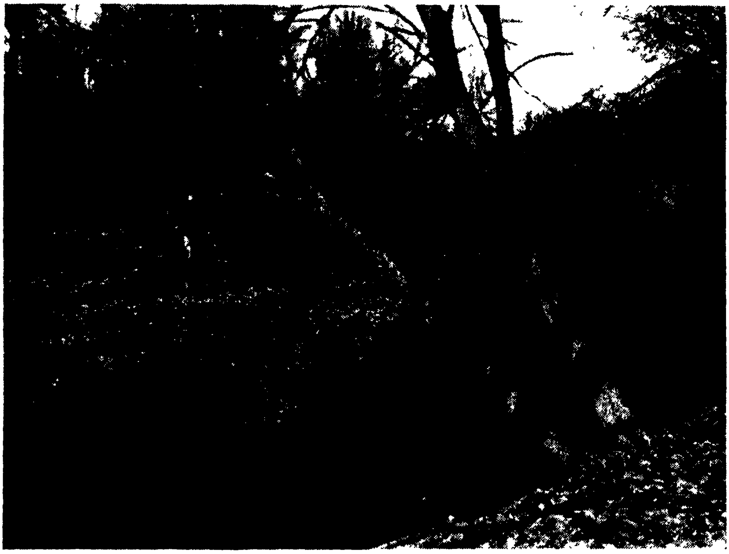

FIG. 3. Upper end of tributary valley. Beaver dam is suggested by noticeable change in gradient of valley floor. Incised channel in foreground, with peat exposed at top.

FIG. 4. Lower end of tributary valley. Mound at right is believed to have been site of beaver house. Valley floor is underlain with peat which is well exposed on the sides of the incised channel.

THE LAMINATED PLEISTOCENE SEDIMENTS OF THE CEDAR RAPIDS REGION*

L. R. Wilson and C. G. Kos

In the vicinity of Cedar Rapids there are extensive deposits of laminated sands within, and adjacent to the valley of the Cedar River and its tributaries. These lie above the till of the Iowan Substage and are associated for the most part with the highest terrace found along the Cedar River and its tributaries in Linn County. The presence of the laminated sediments has been noted by others, but no detailed study appears to have been made of them in the region of Cedar Rapids. During the active building program in Cedar Rapids many exposures were made in basement excavations and furnished a good opportunity for study.

Norton (1895) has briefly described the laminated deposits as preloess sands which, "In origin seem intimately connected with the wash of the till by the water of the melting ice sheet and with the fluvio-lacustrine conditions and slack drainage of the loess epoch which followed." Shipton (1914) described an exposure of "distinctly stratified" sands at 18th street, between E and F avenues in Cedar Rapids, and concluded they were of Pleistocene Age. They were about fifteen feet above the Cedar River, and he decided that they represented an old sand bar. This particular exposure no longer exists, but numerous excavations in that vicinity have shown that the stratified sands described by Shipton are the same type of deposits as are reported in this paper. Leighton (1914) also described (Plate X) a similar deposit in a tributary valley of the Iowa River. Like those in the Cedar valley, the laminated sediments were exposed in a terrace and capped by loess. The deposits are described as of glacial origin, being formed in an overloaded stream or where existed a decrease in gradient. Kay and Miller (1941) have described the Iowan terrace gravels to considerable length and noted their stratification, but have not described the finer sediments in the Cedar Rapids region.

When these laminated sediments were first examined by the senior author, they appeared varve-like, though they were in structural detail definitely unlike such sediments. The laminations are alternately light and dark in color and extend horizontally many feet through the exposures. The laminae vary in thickness from a small fraction of an inch to nearly a foot and are sharply defined. The darker laminae generally contain finer sediments than the lighter laminae. Further investigation has shown that all of these deposits are not horizontal, but also occur dipping at angles of 15° to 25° like the foreset beds in a delta. Also the composition of the horizontal laminae has been found to vary from silt to cobble gravel.

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* Contributions from the Science Laboratories of Coe College, N. S. No. 7.

At present about forty of these exposures have been examined in Linn County. Nearly all are in the valley of the Cedar River and its tributaries. Most of them are in the highest terrace of the Cedar River system, although a few are above this terrace, and are located in what probably were depressions in the Iowan drift plain. All of the deposits showing laminations were found to be covered by a mantle of loess that varies in thickness from several inches to about three feet.

Two good exposures are now present at Van Vechten Park (Fig. 1) and in the quarry directly across the river above the city sewage disposal plant (Old Snouffer Quarries). In both exposures only horizontal lenses are present, though they show a slightly undulating character. The thickness of the deposits is approximately twelve feet, and they are underlain by Iowan glacial drift.

A study of the highest terrace of the Cedar River and its tributaries shows that this terrace on the northward side of the river extends back into the outwash plain of the Iowan ice. This indicates that the age of the terrace deposits is Pleistocene, and their deposition was apparently as suggested by Leighton (1914). Near the Cedar River the highest terrace is approximately forty feet above the present water level.

If the laminated sediments have resulted from melt-water deposition, it would appear that the sediments should be coarser in the vicinity of the moraines. This apparently is the explanation for the coarse, laminated deposits found in the highest terrace in the meander scar of Squaw Creek, in Section 29, Township 83 N., Range 6 W. The moraine of the Iowan ice is about one-fourth mile from the exposure. The lighter colored laminae are composed of cobble gravels, with cobbles ranging up to four inches in diameter. The darker colored laminae are composed of pebble gravel and sand (Fig. 2).

During the retreat of the Iowan ice the valley of the Cedar River was evidently swollen and in places more than a mile wide, as is shown by the areal extent of the highest terrace. Into this swollen river flowed overloaded tributaries of which Cold Stream was one. As the Iowan ice melted back, the length of Cold Stream was extended and it became much braided. Deltaic sediments were laid down in standing or slack water. Subsequently, these glacial sediments were incised and formed the high terrace along the Cedar River and up the channels of the tributary valleys. The discovery of typical deltaic beds of the foreset and topset types in the valley of Cold Stream (Sec. 8, Township 83 N., Range 7W.) (Figs. 3 and 6) led to a stream table experiment which would simulate as closely as possible the development of that valley. The soil used in the experiment came from an excavation on the Coe College campus, and is the same material as the laminated sands. A slope about 10 feet long with a gradient of about 3 degrees was built. This ended in water four inches deep. The depth of the water was controlled and water was supplied from a city main and directed by a rubber hose of one-half inch diameter. The rate of flowage was about one-half gallon per minute. This constructed topography appears to be similar to that upon which the valley of Cold Stream was formed when the Iowan ice began its retreat. The first experiment was run for a period of three weeks. During that time an extensive delta was built up in the water. The stream bed was cut down and later the channel near its mouth was partially filled with sediments. Terraces appeared in the stream-table channel and islands on the delta. The water tank was then drained and the delta was allowed to become partially dry before sectioning was begun. The first section was made longitudinally through the medial part of the delta (Fig. 4). This section showed very diagrammatically the structure of top, fore, and bottomset beds. It was possible to trace many topset beds across the delta to their inclination as foreset beds, and along the bottom of the tank as bottomset beds (Fig. 5). Near the upper end of the delta many of the foreset beds were truncated and overlain by topset beds similar to those shown in the Cold Stream deposit (Fig. 6). The most outstanding feature of this and other sections was the structural similarity of the laminated deposits to those found in the high terraces of the Cedar River.

The second run of the stream table experiment was done with the same material and a similarly constructed topography. However, the speed of the water was increased to about 2 gallons per minute and sediment was fed into the channel at the nozzle of the hose. This increased the load of the stream and built up the delta more rapidly. The experiment was run for one week. After the delta had reached considerable size, it became a subaerial feature upon which distributaries meandered. The tank was drained and the sediments were allowed to become partially dry. Then a medial longitudinal section was cut through the delta and some distance up the channel of the stream. The deposits again showed characteristic deltaic bedding. Again the similarity of the laminations in the stream table deposits and those of the Cedar valley were very striking. The laminae or lenses of silt, sand, and gravel were as definite as they are in the field, and every form that has been seen in the field has been found in counterpart in the delta or channel deposits of the stream table. The alternating lenses of coarse and fine silts appeared to be due to differential sedimentation, i.e., the coarser, lighter colored sediments were deposited in distributaries of greater volume and velocity than when finer, darker colored silts were deposited. These conditions resulted as the main distributaries meandered from side to side across the delta plain.

It is noted above that the Pleistocene laminated deposits are capped by a loess mantle. The graduation of the sub-aqueous and aeolian deposits is imperceptible. Some of the early aeolian silts were apparently deposited in water, and finally, as the Iowan ice retreated and channels were cut into the flood plain, true loess was formed on the terraces. Subsequent down cutting of the Cedar River channel has caused the formation of the high terrace. The lower terraces all appear to be without a mantle of loess indicating their later age, and the time during which the loess mantle of the high terrace was deposited.

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EXPLANATION OF PLATES I AND II

Fig. I. Exposure of laminated sediments in the highest terrace of the Cedar River in Van Vechten Park of Cedar Rapids. The laminae are overlain by subaqueous silt and capped with approximately three feet of loess.

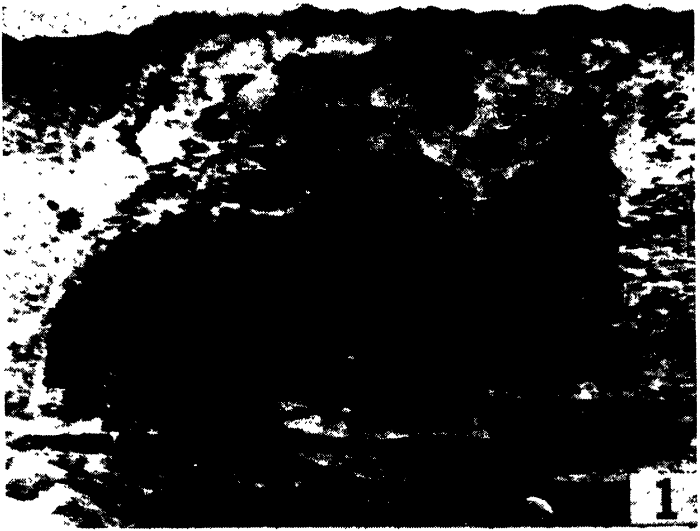
Fig. 2. A lamina of pebble and cobble gravel exposed in the highest terrace of Squaw Creek. Only a lighter colored lamina is shown.

Fig. 3. Foreset beds exposed in the highest terrace of Cold Stream. These dip at angles of 15° to 25° downstream and are overlain by nearly horizontal topset beds.

Fig. 4. Longitudinal section through the stream table delta deposit showing the character of bedding.

Fig. 5. Longitudinal section of the stream table delta, showing bottomset, foreset and topset beds. It is suggested that the exposures illustrated in Figures 3 and 6 are of the type of sedimentation shown in the stream table deposits.

Fig. 6. Exposure of nearly horizontal laminae in the highest terrace of Cold Stream valley, showing the light and dark colored beds in contact with truncated foreset beds. This exposure was located near that shown in Figure 3.



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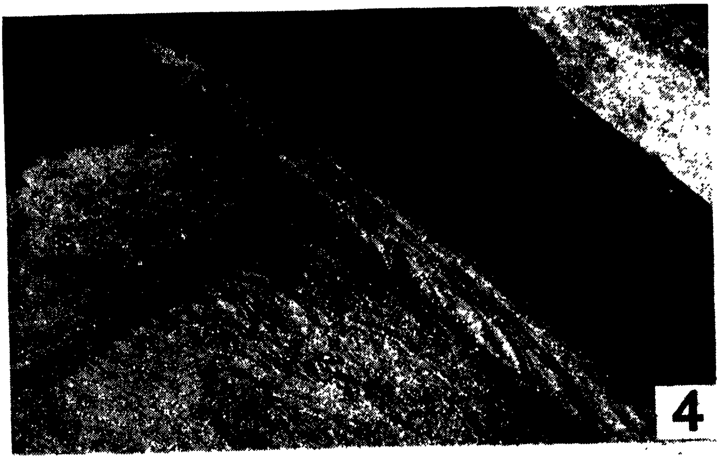

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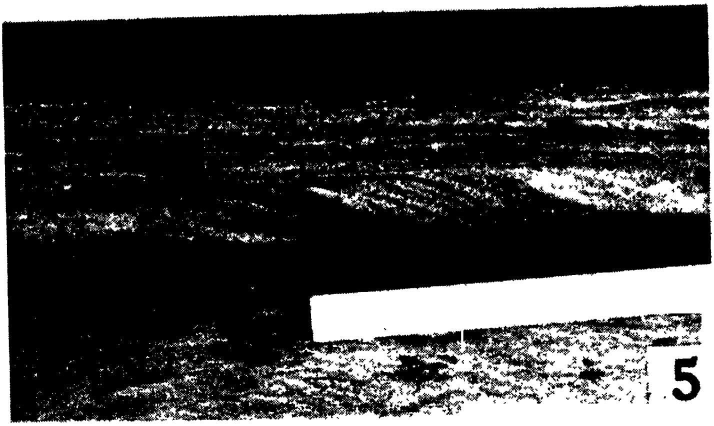

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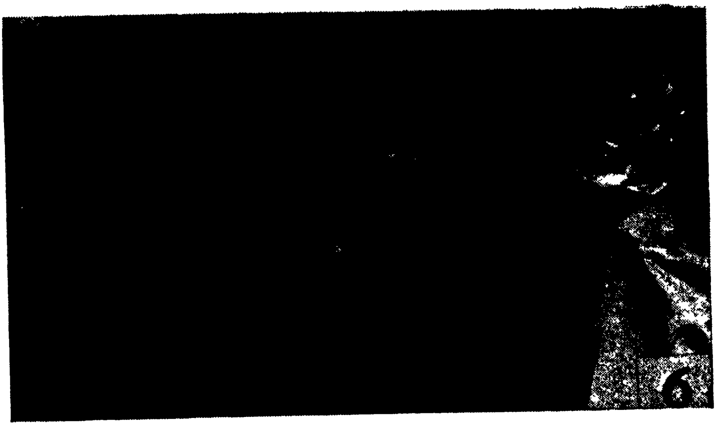

6

DIFFERENT TYPES OF DISTURBANCES APPEARING ON IOWA SEISMOLOGICAL RECORDS.

MRS. M. M. SEEBURGER

The interpretation of seismograms presents numerous problems and offers unlimited opportunities in the field of research. To the geologist it offers means of studying the interior structure of the earth, and familiarity with the unstable regions of the earth.

A pre-requisite to successful interpretation is the thorough understanding not only of the characteristics of earthquake waves as they are transmitted through the earth at various depths and distances, but also such other disturbing factors as tilt, wind tremors, traffic, and the ever-present little trembles called microseisms.

Having all this in mind, it then becomes necessary for the seismologist to familiarize himself with the appearance of these seismic waves and other disturbances as they appear on the grams of his particular station. To this end Des Moines Station is compiling an atlas of typical records of earthquake shocks from different distances and localities, and also typical records of other types of disturbances. A few of these are shown as examples of different types of seismic movements and miscellaneous disturbances appearing on Des Moines grams.

The shocks vary from a "near-by" shock, originating at Tecumseh, Nebraska, 230 kilometers distant, to a Bay of Bengal shock, 15,600 kilometers distant. They range from normal depth, originating within the outer crust of the earth, to a deep-focus shock originating 590 kilometers below the surface. All have been recorded at Des Moines Station since December 1, 1934. Earlier records were mechanically recorded on smoked paper, and have a magnification of 15. Those since January 15, 1937, were recorded photographically, and have a magnification of 125.

Before beginning the examination of different types of shocks, examples of other disturbances will be given.

The first is tilt. (Figures 1 and 2) Tilting of the pier, with consequent displacement of the line, or trace, is caused, at the Des Moines Station, chiefly by moisture in the ground, outside of the basement vault in which the instrument is housed. Thus the spring thaws, or a rainy spell following a drouth, play havoc with the records. Tilt appears on the grams in a widening or narrowing of

Fig. 1. Tilt, shown in the widely spaced lines. This was caused by a cloudburst in Des Moines.

Fig. 2. Tilt caused by moisture pressure during heavy spring rains.

the space between the hourly lines. Frequently the change in pressure on the piers, caused by prolonged rains may cause the lines to overlap each other so that they cannot be read. Later, as the moisture disappears and the pressure on the piers is relieved the lines again appear with normal spacing. An interesting phenomenon occurred on June 29, 1935, when heavy rainfall followed a season of drouth. At that time two instruments were recording on opposite ends of the same drum, one showing east-west movement, and the other north-south. Tilt on one pier caused the lines to separate widely, while on the other they drew closer together. On another occasion the tilt was more rapid than the lateral progress of the drum, so that the lines appeared backward on the gram.

Rapid change of temperature causes some trouble with tilt, but is not serious at Des Moines Station. Tilt problems become more acute as the magnification of movement increases. In Des Moines it would be impractical to operate at a greater magnification than 125 without installing tilt compensation.

Our next most serious obstacle is wind. Wind, striking the house sets up vibrations, which are transmitted to the foundation and from the foundation to the earth, appearing on the grams as irregular groups of rapid vibrations corresponding to the gusts of wind. While they cannot be mistaken for earthquake phases, they handicap the interpretation of a record by obscuring the early seismic phases. For this reason instruments give better service when housed in low buildings. (Figure 3).

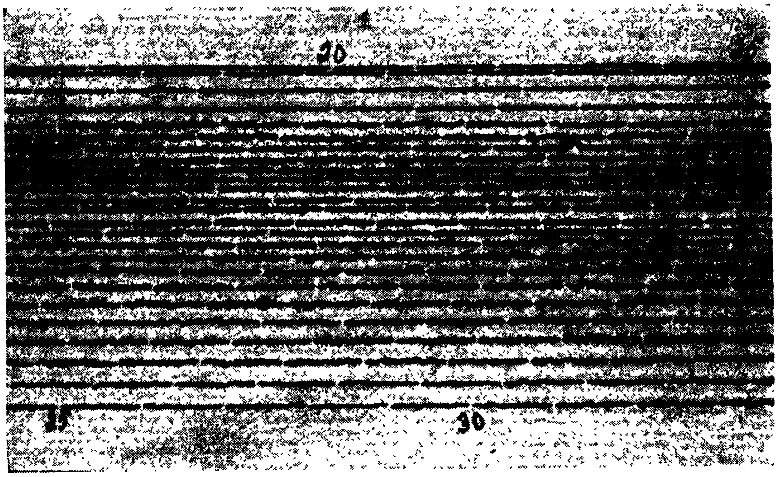

Fig. 3. Wind tremors, showing vibrations in the house, due to gusts of wind, transmitted to the foundation, and thence to the earth and therefore to the seismograph pier.

Traffic appears on the records as small, very rapid vibrations resembling a blur in the record. Since Des Moines Station is not on a heavily-traveled street, that is not a serious obstacle.

Microseisms are nearly always with us. They are the little ripples in the earth, usually of 3 to 6 seconds in period in Des Moines grams. Their amplitude varies, but they are rhythmic in appearance. Since microseisms are often larger than the beginning phases of distant earthquakes they complicate the interpretor's task very greatly. A"P" (first preliminary) phase of an earthquake is sharper than a microseism, but great familiarity with the habits of microseisms and earthquake preliminaries is needed to distinquish between the two. Microseisms are more prevalent at times, appearing almost continuously for days or weeks, and then becoming less conspicuous for a time. Hurricanes on the Atlantic and Gulf coasts often are accompanied by microseism storms. The cause of microseisms, has been the occasion for much research. The theory held by Dr. Beno Gutenberg is that microseisms are caused by the passing of areas of low barometric pressure. (Fig. 4).

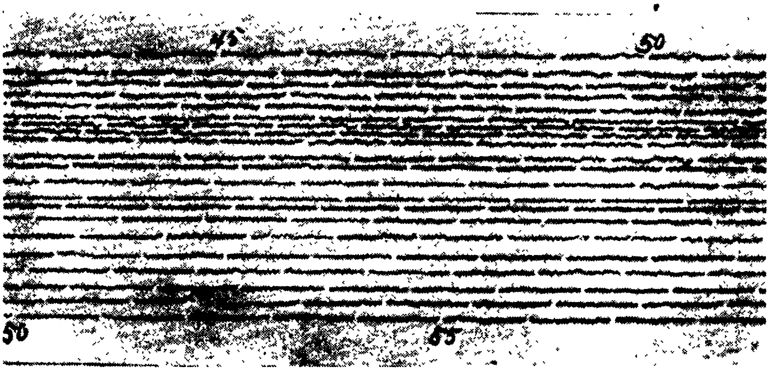

Fig. 4. Microseisms. Always present on the records of sensitive instruments, but more prominent at some times than others.

Earthquake shocks will be considered in the order of their distance. The closest one recorded at Des Moines was the shock originating at Tecumseh, Nebr., 230 kilometers distant, on March 1, 1935. It was felt as far east as the Des Moines River in Des Moines. (Figure 5). A near earthquake appears as a very small trace, consisting of rapid vibrations very close together. A large earthquake close at hand would dismantle the instrument. Special instruments of the shock recorder type are needed for local earthquakes.

Shocks occasionally occur in the Rock Island area, but are usually very small, and scarcely discernible on Des Moines records. New Madrid, Mo., 650 kilometers away, is in the center of an earthquake area, and a shock there would show up on Des Moines records very clearly, since it is far enough away for the phases to be clearly separated. Yet even New Madrid is too close for best results, since all phases from the first preliminary to the

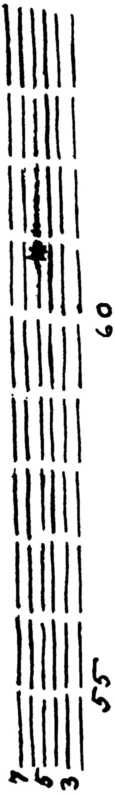

Fig. 5. Near-by earthquake shock, originating at Tecumseh, Nebr.

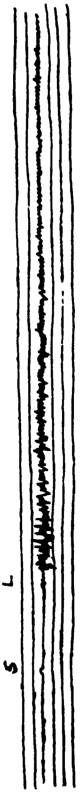

Fig. 6. Earthquake originating in the Southern California peninsula.

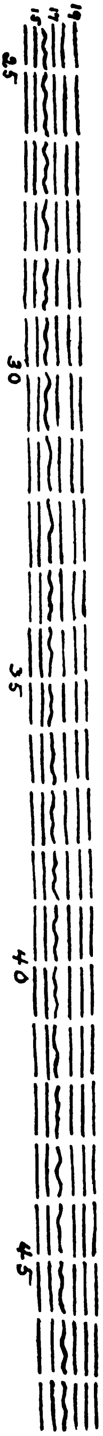

Fig. 7 Destructive earthquake originating at Quetta, India. 30,000 lives were lost.

large surface waves would require only two minutes of space on a Des Moines gram.

A shock in Ohio, 820 kilometers away, showed up well in Des Moines, but the Canadian shock of Nov. 1, 1935, was still clearer. The Helena, Montana, shocks in the fall of 1935, were very distinct, eight of them being of sufficient intensity to register at the Des Moines Station. They were 1560 kilometers away. Salt Lake City, Imperial Valley, and California shocks are a good distance to be clearly recorded here. They vary from 1900 to 2200 kilometers in distance—far enough to show the "P", "S" and "L" waves clearly separated, but not far enough to encounter the numerous reflections and refractions that are apparent in the distant earthquakes.

The two first earthquakes ever recorded at Des Moines Station, in December, 1934, are excellent examples of California Peninsula quakes, 2260 and 2320 kilometers distant. (Figure 6). Mexico contributes a number of shocks to the annual earthquake catalog. One good example is shown on a sharp shock near the heart of Mexico. It now takes approximately 6 2/3 minutes for the first preliminaries to reach Des Moines station, and probably 20 minutes will elapse before the cauda of a strong earthquake will finish recording. A number of shocks are recorded each year from Central America; Honduras, Guatemala, Salvador, and Panama being well represented on the Des Moines earthquake map.

The next group of earthquake shocks, in order of distance, are those occurring in Alaska and the Aleutian Islands. These are quite numerous, and range from 4200 kilometers in Alaska to 6600 kilometers in the Aleutians. The waves now include "PR1" and "PR2" and "SR1" and "SR2" as well as the original "P", "S" and "L" waves. The waves appear less sharp. A little farther off are the shocks in Kamchatka, and in the Argentine and other countries of western South America.

Now we come to Japan, a region extremely seismic, with many shocks each year. Those recorded at Des Moines have ranged from 8650 to 9660 kilometers. The preliminaries come in, on the average, about 18 1/2 minutes after the shock occurs, and may continue on the record for an hour in the case of strong shocks.

Beyond Japan, in distance, Des Moines-recorded shocks become longer and more sinusoidal in character, and the preliminaries harder to distinguish except in very strong shocks. Tonga Islands, Thibet, and Baluchistan, ranging from 10,800 kilometers to 12,000, have recorded shocks in Des Moines. The latter was the destructive shock of May 30, 1935, which caused a loss of thousands of lives at Quetta, India. (Figure 7).

Numerous new waves begin to appear, due to reflections and refractions, and "P". disappears from the record, in what is called the shadow zone at 12,200 kilometers (about the distance of Calcutta). At 14,200 kilometers (about New Guinea), "P1" begins, and the shadow zone ends. The Philippine Islands fall within this shadow zone. Des Moines Station has recorded shocks from Solomon Islands, Calcutta, New Guinea, Philippine Islands, and the Celebes Sea, within this zone.

Beyond the shadow zone very few preliminaries may be identified, except on extremely strong shocks, but the long, sinusoidal L waves come in clearly and continue for a long time, so that the entire record may require two hours to come in. Such were several shocks near Sumatra, which have been recorded here.

Of special interest are the deep focus quakes, which have been the subject of much research. They differ materially from the shocks occuring within the earth's crust, which have very large surface ("L") waves, in proportion to the preliminary waves. With plutonic earthquakes (those originating below the discontinuity at the base of the earth's crust) the surface, or "L" waves are reduced in size, their size diminishing as the depth of the earthquake increases. Travel times for earthquake waves are different for deep focus earthquakes and a graphic chart for the determination of the focal depth, time of occurrence, and epicentral distance, is used. A number of deep focus shocks have been recorded at the Des Moines Station, including one in Argentine, on January 14, 1936, which originated 590 kilometers below the surface. A Tonga Island shock, April 16, 1937, originated 400 kilometers below the surface.

Earthquakes recorded at Des Moines average about sixty a year. During the last nine days five have been recorded, all originating outside the United States.

DES MOINES SEISMOLOGICAL STATION,
DES MOINES, IOWA.

SURVEY COURSES IN MATHEMATICS

O. C. Kreider

Many ideas have invaded mathematical discussions in recent times and have pointed out the need for survey courses in mathematics. By some, the people who presented these ideas have been considered fifth columnists to entice us away from our national traditional courses in mathematics. In our present crisis we find our national educational domain disarmed and at a disadvantage in the mathematical field.

True, the power of accurate computation, quantitative thinking, and logical reasoning has not perished in our nation, but traditional mathematics has not fulfilled the mission of mathematics in the educational scheme. Too large a group has been side stepping the traditional courses, hence the embarrassing results in the present crisis.

There are two common ways of reaching this large group of students. One is guidance and much of the so called guidance just now is the same as pressure. The other way is to admit our glaring weaknesses and attempt doing something about them. If we must add new courses to allow mathematics to fulfill its mission then we should not hesitate to make the necessary change. With the proper courses the guidance problem will be simplified.

In a few cases the survey program has invaded the realm of mathematics instruction. Some have been alarmed but others have encouraged its entrance. For the past few years the speaker has been interested in every text, old and new, which might be used as a text for a survey course. As would be expected the texts or courses were very cosmopolitan, yet they were rather easily classified into a half dozen distinct types.

Most of the *Review Types* regard mathematics as computational with little or no concern with the question of how to avoid extensive calculation. Arithmetic is dominate. The order is generally haphazard and the chapters unrelated. Such a course would have the greatest value to prospective grade teachers or nurses.

The *Eclectic Type* contains three books in one, namely college algebra, trigonometry, and analytic geometry or the arrangement of topics of the three subjects to achieve a little relationship between chapters. It could be used in most traditional courses.

One of the *Analysis Type* stresses the mathematics used in various vocations. It is of course important to know the mathematics that is being used in various vocations but an interesting question is, what mathematics may be used to advantage that are not in use now?

The other *Analysis Type* introduces algebra, trigonometry, analytic geometry and some calculus. The arrangement of topics is traditional with the notion of functions at the outset. Generally the graphical methods of functional relations are gradually refined and differential calculus introduced.

The *Cultural Type* is characterized by its essay form and challenging figures of speech. The induction of the student into the various fields of human learning via mathematics is the chief objective. A few of these books are being used as texts and most of them would be fine supplementary material. Generally speaking most of them are too difficult for the average freshman with two years of high school mathematics.

Books vary in the *Historical Type* from the minimum represented by a straight mathematics course with a sprinkling of historical notes to the history book with a sprinkling of mathematics. Most of the books have a fine way of showing use and effect in the social need.

The *Psychological Type* takes account of the psychic processes in the boy in order to grip his interest. Mathematics is associated with everything that is seriously interesting to the pupil at that particular state of his development.

Today survey mathematics is well known, but not a very well defined term. There have been associated with it many shades of meaning and interpretation, yet they all represent efforts to bring out values held to be more or less submerged in the traditional courses. Few writers or committees venture to make any except broad general recommendations. However, it seems to the writer that a few rather distinct characteristics should be adhered to.

The main characteristic of survey mathematics is breadth, i.e. survey courses are not confined to a small single body of subject matter. Not only is the mathematics scope broader, but many nonmathematical notions are included to complete the understanding of certain principles.

The second characteristic of survey mathematics is psychological organization. Many will at once cry out for logical organization because it is more easily achieved. To present a subject logically and enable a student to understand it logically are not always the same. If the teacher must take into account the psychic processes in a boy in order to attract his interest, why not write a little of it into books?

The third characteristic of survey mathematics is value. Three values uppermost at the present time are: (1) comprehensive principles (2) cultural contributions and (3) utility.

After considering the discussions concerning the improvement of mathematics the next turn is to the guidance of our best students toward mathematics. But in no way should the other type of students be excluded. The key note for a survey course should be: Make mathematics really and obviously worth while to students and encourage students rather than eliminate them.

Ellsworth Junior College,
Iowa Falls, Iowa

REPORTS

THE RECIPROCAL BENDING-TORSION EFFECT FOR LEAD SINGLE CRYSTALS

STANLEY BRUNTJIN

A single crystal rod subjected to a pure axial torque also bends. Direct measurements on this effect have been made for lead single crystals.

ADIABATIC COMPRESSIBILITIES OF SOME AQUEOUS SOLUTIONS AND THEIR VARIATION WITH THE INDICATED LIQUID STRUCTURE OF THE WATER

VICTOR B. COREY

Adiabatic compressibilities of aqueous solutions of twenty-seven strong electrolytes were determined by measuring the velocities of a supersonic wave of approximately 10^6 cycles. When the values of the partial molal volumes of the solute, water, were computed, there was found a striking correlation of these values with the adiabatic compressibilities. An exact correlation cannot be expected both because of the empirical nature of the formulas used and also because there is no reason to suppose that the altered structure of the water is of the same kind in every electrolyte. The results, however, are strongly indicative of the view that ions alter the structure of the solute, the water becoming more dense with ionic concentration.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

ADIABATIC COMPRESSIBILITY OF ELECTROLYTIC SOLUTIONS AND THE X-RAY DIFFRACTION INTENSITY DISTRIBUTIONS

V. B. COREY AND G. W. STEWART

A study of the adiabatic compressibility and the X-ray diffraction intensity distributions of twenty-six strong electrolytes shows a correlation to the following extent. If one compares the rate of change of adiabatic compressibility per mole with the rate of change of the minor X-ray diffraction peak per mole in two thirds of the twenty-six samples these values increase in magnitude together. If one plots the values of the former, changing from one to eight times, and of the latter varying sixty times, the points are included within an angle of about 35° (with one exception). This approximate correspondence adds credence to the view—obtained on other grounds, that the water structure alters by the breaking of H bonds and that this is the chief cause of the variations in the adiabatic compressibility.

State University of Iowa,
Iowa City, Iowa

A SIMPLIFIED CONDUCTIVITY-RADIATION EXPERIMENT FOR THE ELEMENTARY LABORATORY

Lester T. Earls

In an attempt to fill a need for the laboratory approach to the physical processes of conduction and radiation of heat, the following two-part experiment is suggested:

The heat conductivity of a poorly conducting specimen (such as wool cloth) is measured by allowing heat to flow through it from a hot cup above into a copper receiving block below. Direct measurements permit the calculation of the coefficient of thermal conductivity with an accuracy which is adequate for the elementary laboratory work. The heat-absorbing characteristics of various surfaces are tested by using them to face copper blocks of similar dimensions, and radiating them with the heat and light radiations from either a cone-type radiant electric heater or a 200-watt electric light.

Typical data taken by elementary physics students in a three-hour laboratory period are presented and discussed.

Iowa State College,
Ames, Iowa

CONCERNING PHYSICS APTITUDES

C. J. Lapp

The search for physics aptitudes extends back to 1926 when eight were tentatively listed. The checking and rechecking of these have resulted in discarding of six. Of the many new aptitudes suggested and studied, four new ones have been discovered. The inter-correlation, however, reduces the predictive value of the added new ones. Five of the aptitudes have been built into an experimental edition of a new test and it is now being experimentally used in the E.S.M.D.T. course in Pennsylvania and elsewhere. This test gives a correlation with Mechanics Cooperative Test, Form A, score of .72.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

THE RATING OF PHYSICS TEACHERS IN THE PENNSYLVANIA SUMMER ENGINEERING DEFENSE TRAINING PROGRAM

C. J. LAPP

Each physics teacher was given a subjective rating by a traveling physics supervisor after the teacher had been visited at least three times. After the teacher had been visited five times the physics supervisor rated the teacher objectively on a rating blank containing twelve items on a five point scale. Finally each teacher was rated on the basis of the achievement of his students as compared to the average achievement of all students in the program of equal ability after corrections had been made for aid received by those students in the research group.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

SOME NEW LIGHT ON THE OLD PROBLEM OF LEARNING IN PHYSICS

C. J. LAPP

Educational psychologists have given significant facts concerning human forgetting. To combat forgetting an experimental research program was organized and carried out in the Summer of 1941 in the Pennsylvania Summer EDT in physics. Devices used to offset forgetting and produce achievement were highly successful.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

ANODE EFFECT IN A COMMERCIAL RADIO TUBE

A. Owens

The anode effect has been studied on the grid and found to be in agreement with results previously published. Attention was then shifted to the plate where the anode effect was studied at larger current densities. It is to be noted that the building up of the effect can more easily be observed on the plate and the decay more easily observed on the grid.

SOME EFFECTS ASSOCIATED WITH NEGATIVE CORONA ONSET

L. E. Pinney

Using concentric cylinder electrodes, observations were made on negative corona in hydrogen, argon, and nitrogen at pressures between 1 and 10 cm. of mercury. Positive ions produced by X-rays passing through argon in the corona chamber produced no measurable secondary effects at potentials below onset. Currents maintained by photo emission from the cathode became unstable at a potential near but definitely below onset.

Iowa State College,
Ames, Iowa

THERMAL EXPANSION OF SINGLE CRYSTALS OF ZINC

William P. Staker

The thermal expansions of sixteen zinc single crystals have been measured in the temperature range 20°-100° C. The expansion coefficient is constant and obeys the Voigt symmetry relation.

PLASTICITY OF ZINC SINGLE CRYSTALS

E. P. T. Tyndall

Some observations are presented of the plastic flow of zinc at very small stresses, just beyond the elastic limit.

RELATIVE INTENSITIES IN THE HOLLOW-CATHODE DISCHARGE

E. H. Winger

The effects of various cathodes of different internal dimensions on the relative intensities of PbII lines in the hollow-cathode discharge were investigated. The discharge was operated in Helium at a pressure of 1.5 mm. Hg and currents of 175 milliamperes. Results were obtained showing a definite variation in relative intensities with changing cathode dimensions. The differences were the most marked for the larger cathodes and actual intensities and temperatures were found to be greater in the larger cathodes. Except for a few exceptions, explainable in a qualitative manner by a consideration of the perturbations involved, the results proved to be quite consistent for all spectral lines considered.

Iowa State College,
Ames, Iowa

THE PREDICTION OF SCHOLASTIC SUCCESS IN A COLLEGE OF LAW

MICHAEL ADAMS

The present study was undertaken as part of a research program directed toward making available to personnel counselors at the University of Iowa a more adequate basis for advising students who contemplate entering the University College of Law. Specifically, it was the purpose of this study to investigate the value of pre-law grade point averages and certain aptitude test scores as predictive indices of success in first year law at the State University of Iowa.

Because of the variations in grading standards at different undergraduate colleges only those students who completed all of their undergraduate work at the University and who had complete records for one year of work in law were included in the major portion of the study. These students were selected from entering classes for the years 1936 to 1939 inclusive. The number and percentage selected from each class are presented in Table I.

TABLE I

Number and Percentage of Students Selected from Various Freshman Classes in the College of Law

Year	Total Enrolled*	No. Used	Percentage
1936	85	33	38.82
1937	96	38	39.58
1938	99	39	39.39
1939	107	42	39.25
Total	387	152	39.28

*The total number enrolled in each class includes students completing their pre-law work at other institutions in whole or in part, those who withdrew in the course of the year, and those registered as freshmen for more than one year.

The predictive indices available for this group of 152 students included grade point averages for pre-law work in the College of Liberal Arts, and scores on the Iowa Qualifying Examination. The Iowa Qualifying Examination, administered to all entering freshmen, consists of the Iowa High School Content Examination, Iowa English Training Examination, Iowa Mathematics Aptitude Test, and the Iowa Silent Reading Test. A composite score, consisting of a weighted total of the raw scores on the four examinations, is computed and used in conjunction with the sub-test scores to assist counselors in advising students and to predict scholastic success at the undergraduate level. The raw scores on the sub-tests and the composite score had been converted to percentiles and were available in this form. It was assumed that these percentiles were equivalent from year to year. For purposes of computation the percentiles were converted to linear scores by the use of Guilford's adaptation of Hull's table (Guilford, 1936).

On the basis of findings of similar studies in other schools of law (Husband, 1939) (Crawford and Gorham, 1940) it was decided that it might be profitable to study the predictive value of the total pre-law grade point averages, the junior year pre-law grade point averages, the pre-law grade point averages in social sciences, and the pre-law grade point averages in physical sciences separately.

The criterion of success in first-year law consisted of the student's final class rank at the close of the academic year. For computational purposes, normalcy was assumed for the class ranks of each year and the ranks converted to linear scores.

RESULTS

The performance of these students in the aptitude tests and pre-law work studied is shown in Table II. The mean linear scores of this group on the Iowa Qualifying Examination composite and sub-tests are definitely superior to the scores of Liberal Arts freshmen as a whole, but the range is very wide. In the case of the qualifying composite the mean linear score of 58.97 is equivalent to a percentile score of about 67 on University norms; but the range extends from the fifth to the ninety-ninth percentile. The mean total pre-law grade point average of 2.58 achieved by these students is also definitely superior to the grade point average of about 2.20 received by students of the Liberal Arts College as a whole. Again the range is wide, however, extending from a grade point average of 1.55 to one of 3.94. From these data we may conclude that the average University of Iowa undergraduate who enters the College of Law at Iowa is definitely superior, as a freshman, on the Iowa Qualifying Examination and maintains this superiority in his pre-law undergraduate work.

TABLE II

Student Performance in the Iowa Qualifying Examination and Pre-Law Work

Predictive Index	N	M	S.D.	Range	
Iowa Qualifying Examination:					
1. Composite Score	152	58.97	16.32	Linear Score	18-93
				Percentile	5-99
2. High School Content	152	59.98	16.79	Linear Score	21-93
				Percentile	7-99
3. Silent Reading	152	57.02	16.30	Linear Score	11-93
				Percentile	2-99
4. Mathematics Aptitude	152	58.12	18.23	Linear Score	3-93
				Percentile	1-99
5. English Training	152	53.52	16.09	Linear Score	14-93
				Percentile	3-99
Total Pre-Law G. P. A.	152	2.58	.501	1.55 - 3.94	
Jr. Yr. Pre-Law G. P. A.	152	2.67	.553	1.47 - 4.00	
Soc. Sci. Pre-Law G. P. A.	152	2.65	.490	1.73 - 3.95	
Phys. Sci. Pre-Law G. P. A.	152	2.47	.647	1.17 - 4.00	

TABLE III

Correlation of the Predictive Indices with the Criterion

	N	r	P.E.
Iowa Qualifying Examination:			
Composite Score	152	.471	.044
High School Content Examination	152	.376	.049
Silent Reading Test	152	.425	.046
Mathematics Aptitude Test	152	.338	.050
English Training Examination	152	.418	.047
Pre-Law Grade Point Averages:			
Total	152	.668	.031
Junior Year	152	.615	.035
Social Science	152	.642	.034
Physical Science	152	.462	.045
Total*	361	.579	.024
Junior Year*	361	.554	.025

*A supplementary study was made of these two indices for the total group of 361 students who completed the first year of law during the years studied.

Inspection of Table III reveals that a moderate correlation of .47 exists between the composite scores on the Iowa Qualifying Examination and the criterion of success in first year law. The correlations between the sub-tests of the qualifying examination and the criterion range from .34 for the mathematics aptitude test to .42 for the silent reading test. These correlations are too low to justify the use of a regression equation based on qualifying scores alone for purposes of individual prediction. However, inspection of the scatter-diagrams suggests a critical linear score of 35 or 40 in the composite score of the qualifying examination, since only ten students with linear composite scores below 40 succeeded in surpassing the lowest twenty-five per cent of the total group in first year law grades.

Of the nine indices studied, the total pre-law grade point average constitutes the most valid single index of success in first year law, correlating .67 with the criterion. Attempts to improve the predictive value of this index by the method of multiple correlation yielded almost negligible results, the highest multiple correlation obtained being .68 when the Iowa Qualifying Examination composite scores were added. Although a value of .67 approaches the upper limit of correlations ordinarily found between predictive indices and academic grades, an inspection of the scatter-diagram indicates that considerable caution must be observed in using the total pre-law grade point average in the prognosis of individual performance in law school. It was found, for example, that twenty-one of the thirty-eight students falling in the lowest quarter of the distribution of total pre-law grade point averages for this group surpassed the lowest twenty-five per cent of the total group in first year law grades, three falling in the upper twenty-five per cent of their respective classes. The relationship between total pre-law grade point averages and rank in first year law class is summarized in Table IV.

Table IV

Relationship between Total Pre-Law Grade Point Average and Rank in First Year Law Class.

Total Pre-Law Grade Point Av.	Rank in First Year Law Class			
	Highest 25%	Second 25%	Third 25%	Lowest 25%
Highest 25% (2.87-3.94)	29	6	1	2
Second 25% (2.46-2.86)	8	16	11	3
Third 25% (2.22-2.45)	4	12	16	6
Lowest 25% (1.55-2.21)	3	9	9	17

CONCLUSIONS

The data seem to warrant the following conclusions for the population included in this study or similar populations:

1. Total pre-law grade point averages are superior to the other indices studied for the prediction of success in first year law. Addition of the other indices by the method of multiple correlation does not materially improve the predictive capacity of total pre-law grade point averages.

2. The correlation between the scores on the Iowa Qualifying Examination and the criterion of success in first year law is too

low to be of much value for individual prediction. However, the data suggest a critical score which might be used by counselors in advising students who seek information concerning their capacity for the study of law.

3. Counselors at the University of Iowa must take into consideration factors other than the qualifying examination scores and grade point averages in appraising the capacity of individual students for success in law school. Somewhat inferior achievement on the qualifying examinations and in pre-law work may apparently be compensated by superior motivation, interest and, possibly, special abilities unique to the study of law.

4. Improvement of our ability to predict law school performance will require the development of tests which evaluate more accurately the specific intellectual characteristics most important for the study of law, methods of measuring objectively the factors of interest and motivation, and improvement of the criterion of success in the law school itself.

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THE RELATIVE SCHOLASTIC ACCOMPLISHMENT OF TWO CLASSES OF COLLEGE FRESHMEN

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INTRODUCTION

Beginning with the year 1941-42, the freshmen entering Grinnell College found a very different educational program from that of the last few years. The new program included the introduction of the four-course plan. Under this plan all courses meet four times a week and give four hours credit, and nearly all students carry four courses each semester. In addition, each freshman takes an orientation course, which last year carried one hour credit, and this year is compulsory but without credit.

A counselling program for freshmen was also introduced. Besides furnishing more assistance during the period of registration, it provides guidance throughout the year. Each freshman has an individual conference with his advisor every two weeks. Problems of personal and scholastic adjustment, including study habits and time-use schedules, are discussed at these conferences.

A third change affecting freshmen was made in the field of student employment. No freshman student is now permitted to obtain college employment during the first semester.

Since it seemed probable that such reorganization would affect student performance, an attempt was made to measure some of the resulting changes.

Specifically, this study was conducted to determine the difference in academic performance between selected groups of freshman students entering Grinnell College in 1940-1941 and comparable groups entering in 1941-42, and to make such inferences regarding causation as seemed justified.

MATERIALS AND PROCEDURE

The data necessary for this study were gathered from the office of the registrar. These data consisted of the total number of hours carried by each student and the total number of grade points earned by each student during the first semester, for all the freshmen entering in 1940-1941, and 1941-1942. According to the Grinnell College grading system a student may earn grade points ranging from zero to four for each credit hour. This makes possible the computation of a grade point average for each student by dividing the total number of grade points earned by the total number of credit hours carried.

In order to have comparable groups from each class, three matched groups were selected. The first group included all freshmen who entered Grinnell from the highest third of their high school classes and who ranked in the upper half of the American Council on Education tests (the scores determined by the tentative national norms) and a reading examination. For the year 1940-1941 this reading examination was the Iowa Silent Reading Test; for the year 1941-1942 it was the Nelson-Denny Reading Test. The second group consisted of those who entered college from the middle third of their high school classes, and were in the middle fifty per cent on both the A.C.E. and reading examinations. The third matched group consisted of students who ranked in the lowest third of their high school classes and who were in the lowest half on both the A.C.E. and reading tests. These primary groups were further sub-divided according to sex.

The mean grade point average was determined for each of these groups and the differences were found for each matched group. The significance of these differences was compiled by the Fisher *t* test.

To supplement these data further, the grade point average for the men and the women of each class was computed. These totals, of course, included many students omitted from the matched groups.

RESULTS

The data indicate that the mean grade point averages of the 1941-42 freshman groups exceeded those of the 1940-1941 freshman groups, except in the case of the middle third group of men.

The men of the first group had a difference of .139, which, interpreted by the *t* test, means that this difference will occur 50% more often than chance. The men of the second group differed .230 grade points, and such difference will occur 80% more often than chance. The men of the third group had a difference of .04, indicating a little better than chance difference. The women of the first group differed in their mean grades by .415 of a grade point. The *t* test indicates that such a difference will happen 90% more often than chance allows. The second group of women differed by .389 of a grade point, and this difference will happen 80% more often than chance. The women of the third group differed .827

of a grade point, which difference could be due to chance in only 1% of the cases. Taking the classes as a whole, the men differed but .185 of a grade point, and the women differed not at all. As checked by the critical ratio, the differences of the whole classes by sex were not significant (only 26% better than chance in case of the men). There are several possible explanations for the fact that the matched groups differed significantly while the classes as a whole did not. The classes included people who ranked high in a very small high school class, but lacked sufficient scholastic aptitude to be included in the top group at Grinnell College. The total groups included also students with reading difficulties, and students with high scholastic aptitudes who had not been motivated to use their ability in high school. The matched groups rejected all such persons of inconsistent scholastic behavior.

Table I—Mean Differences of Matched Freshmen Groups

Matched Groups	Degrees of Freedom	Mean Diff*	t (Fisher)	Significance of mean diff. better than chance
Men Group I	51	.139	.679	50%
Men Group II	26	-.230	1.31	80
Men Group III	8	.040	.435	30
Women Group I	96	.415	1.700	90
Women Group II	15	.389	1.39	80
Women Group III	8	.827	3.44	99
Men of whole class	186	.185	.69	26
			(Critical ratio)	
Women of whole class	218	0	0	0

* These differences represent how much the 1941-1942 freshmen exceeded the 1940-1941 freshmen.

In interpreting the results of this study, several general notions should be kept in mind. In the first place, grades of the freshman class as a whole tend to form a normal distribution. Standards upon which grades are given may be raised or lowered, but approximately the same proportion of each grade will be given. The newness of the four-course plan should be considered, as it might change grading standards. The fact that freshmen students carried a heavier hour-load in 1941-42 is also important. It would probably make good grades more difficult to obtain, although the integration of study effort might allay this. These factors undoubtedly influence academic performance, although their influence is not easily measured.

CONCLUSIONS

Mean grades of the respective first semesters of the matched freshmen groups were higher in 1941-1942 than in 1940-1941.

These differences were reasonably significant in four of the six matched groups. Since the classes as a whole were about equal in performance, it seems fairly safe to conclude that students who are consistent in their ability and previous performance are doing better work under the four-course plan than under the previous system. Studies conducted when the new plan is more firmly established should be even more significant.

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OCULAR PHOTOGRAPHY AS A SCIENTIFIC APPROACH TO THE STUDY OF ART

HERMAN F. BRANDT

Regardless of how we look at art we project into the art object the response as expressed by individuals. Whether we judge design or color we evaluate it in the light of our own response to it. Since this is the general procedure in arriving at a decision in judging paintings or statuary we need to make inquiry as to just what behavior is involved in making such a choice.

From the findings of experimental laboratories of artists and psychologists it is apparent that artists as individuals or as a class are attempting to arrive at a criterion for judging the adequacy of artistic creations. Without reviewing the various techniques employed by experts in arriving at a standard for judging art, the author of this paper proposes to evaluate the response to art objects by analyzing the ocular patterns of subjects observing specified designs.

PURPOSE OF THE STUDY

The purpose of this study is an attempt to evaluate by means of Ocular Photography the stimulating effects of designs when presented in pairs to observers. It is further an endeavor to find an answer to such questions as:-

1. *What relative time do subjects spend on cards when selecting one of two designs regardless of their preference?*
2. *What is the relative excursion frequency of subjects when selecting one of two designs?*
3. *What is the ratio of attention time to excursion frequency when subjects observe designs mounted in the vertical or horizontal plane?*
4. *What relative attention time is devoted to preferred and non-preferred designs according to the judgment of the observers?*
5. ***What relative attention time do subjects spend when observing cards in the order of sequence?***
6. ***What relative attention time is devoted by subjects on designs when their selection agrees or disagrees with the choice of experts?***

Finally this research study is an attempt to ascertain whether correlations can be established between the so called laws of color and composition and eye movements.

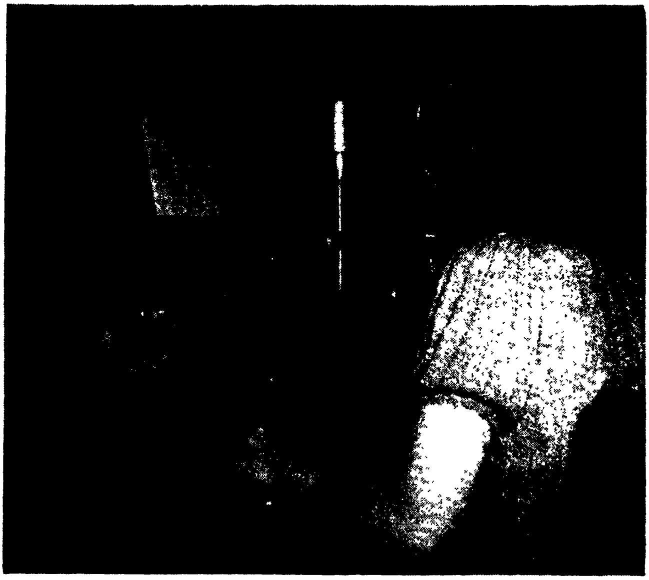

Fig. 1. Portable eye camera and exposure card[1]

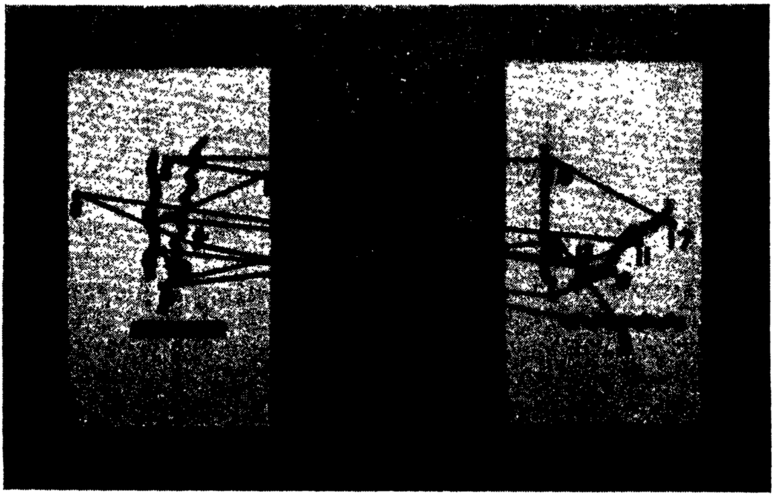

Fig. 2 Ocular pattern of subject 18 observing card #5

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[1] The eye camera was invented and developed by the author of this study.

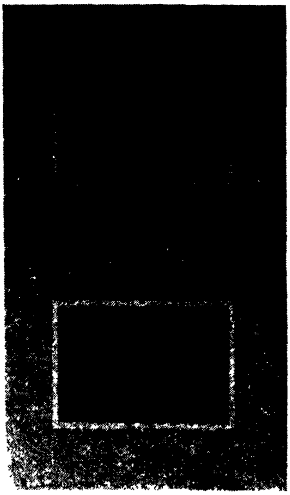

Fig. 3 Ocular pattern of subject 13 observing card #14

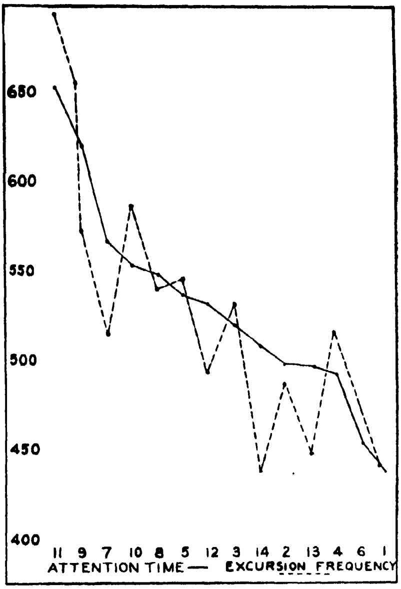

Fig. 4 Relative attention time to excursion frequency

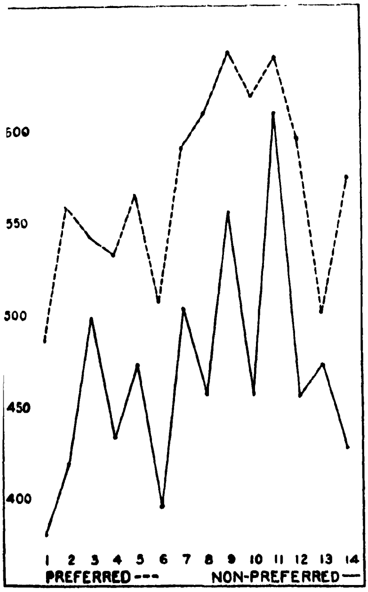

Fig. 5 Attention time of preferred and non-preferred designs

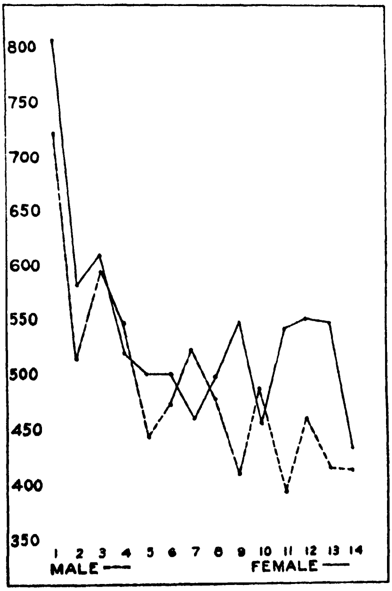

Fig. 6 Attention time of respective cards in order of sequence

PROCEDURE

Subjects: Fifty-six subjects, 28 male and 28 female, (college students selected at random) were asked to observe 14 pairs of designs. (The designs are the creation of Maitland Graves which appeared in the August, 1941 issue of the American magazine, pages 96-97 and are described in detail in his book "The Art of Color and Design.")[1]

Exposure cards: Each pair of designs was mounted on a card 5¼ x 6 inches with a neutral gray background and presented to each of the 56 subjects with the following instructions:—"Here is a test that will enable you to determine for yourself to what degree you are gifted with good taste. On these cards are 14 pairs of designs. Study each pair carefully and decide which one appeals to you most. Don't be too analytical about it, just pick the one in each pair that strikes you as more unified, better balanced or more appealing than its mate. As soon as you have decided which of the two designs is better record your answer."

The sequence of the cards was rotated so that every card appeared in every position of the series. This procedure was followed in order to eliminate the interest or fatigue factor. The identification numbers used on each pair of designs is identical to the numbers used in the American magazine.

Apparatus: Subjects were photographed with an eye camera illustrated in Fig. 1. This portable bidimensional eye camera photographs accurately every eye fixation as well as every movement. The location, duration and sequence of every fixation is obtained by this technique together with the number, direction and distance of the excursion[2] accompanying the fixations.

RESULTS

In order to accommodate the reader in obtaining information relative to the general problem of the Laws of Composition and Eye Movements as revealed by Ocular Photography the author provides the answers based on this study in the order listed under the caption of the purpose of this study.

1. *What relative time do subjects spend on cards when selecting one of two designs regardless of their preference?*

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[1] Graves, Maitland, "The Art of Color and Design," McGraw Hill Book Co. 1941, New York and London

[2] An excursion is an eye movement from one fixation to the next.

Table I

Relative time subjects spend on cards regardless of preference*

Card No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Ave.
Male	4.82	4.96	5.27	4.27	4.80	4.00	5.71	4.93	5.41	5.27	5.71	5.27	4.43	4.73	4.97
Female	3.87	4.86	5.18	5.46	5.71	5.07	5.32	5.78	6.61	5.55	6.86	5.18	5.36	5 32	5.44

* All time is recorded in terms of seconds or a fraction thereof.

Based upon the above table the male subjects spend an average of 4.97 seconds on each of the 14 pairs of designs while the female subjects spend an average of 5.44 seconds while observing the same cards. This is an average of 5.21 seconds per card for both male and female subjects. It is apparent that female subjects spend more time in making their selection than do male observers.

2. *What is the relative excursion frequency of subjects when selecting one of two designs?*

It seems natural that subjects in selecting one or two designs make excursions from one to the other in an attempt to arrive at a decision. Whether this difference for preference is obvious or concealed to the observer may determine for him the relative number of excursions necessary in making his selection.

Table II

Relative excursion frequency of subjects observing designs mounted vertically and horizontally.

Card No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Ave.
Male	4.50	4.89	5.21	4.57	5.00	4.14	5.32	4.96	5.21	5.89	6.39	4.86	3.93	4.71	4.93
Female	4.29	4.71	5.14	5.57	5.64	5.21	4.71	5.57	5.93	5.54	7.18	4.86	5.00	4.64	5.29

Male subjects according to the above table make an average of 4.93 excursions per card when selecting one of two designs, while female subjects make an average of 5.29 excursions for each card. As in attention time female subjects exceed their male competitors in excursion frequency while making their selection. In computing the relation of attention time to excursion frequency of 4.97 to 4.93 for the males and 5.44 to 5.29 for the female subjects, we arrive at a ratio of 1.00:.99 to 1.00:.97 for the two groups respectively. Female subjects make fewer excursions per unit of time than their male competitors. Both groups make an average of almost one excursion for every second of observation time.

Table III

Correlation of attention time and excursion frequency for cards 1-14

Card No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Ave.
Av. Att. Time	4.36	4.91	5.22	4.87	5.26	4.54	5.12	5.36	6.02	5.41	6.28	5.22	4.89	5.03	5.21
Av. Exc. Freq.	4.39	4.80	5.18	5.07	5.32	4.68	5.02	5.27	5.57	5.71	6.79	4.86	4.46	4,35	5.11

Subjects spend an average of 5.21 seconds per card and make 5.11 excursions during the same observation time. The correlation between attention time and excursion frequency is .763 for all subjects participating.

Based on the correlation of attention time and excursion frequency it is apparent that whenever more time is spent on a certain card the excursion frequency is increased proportionally. The highest deviation of attention time to excursion frequency is for cards 3, 9 and 12 while a perfect relation exists for cards 1, 5 and 10. Card no. 11 has the highest attention time and excursion frequency while card no. 1 the lowest in both measures of ocular performance.

Figures 2 and 3 represent typical ocular patterns resulting when a subject observes designs with the intention of selecting the one which according to his own judgment of good art is preferred.

3. *What is the ratio of attention time to excursion frequency when subjects observe designs mounted in the vertical or horizontal plane?*

Designs mounted horizontally appear on cards 1, 2, 3, 4, 5, 6, 10 and 11 and designs mounted vertically appear on cards 7, 8, 9, 12, 13 and 14.

Table IV

Relative excursion frequency of subjects observing designs mounted vertically and horizontally.

Design Mounted	Attention Time	Excursion Frequency	Ratio
Horizontally	5.11	5.24	1.00:1.03
Vertically	5.34	4.92	1.00:.92

The results as tabulated in Table IV corroborate the findings of earlier studies which revealed that vertical eye movements are inhibited while horizontal ones (other things being equal) are facilitated.[4] More time is spent on cards when observing designs mounted vertically than when such combinations are displayed horizontally. Although observation time is prolonged fewer excursions are executed in the same unit of time.

Figure 4 indicates that considerably fewer excursions were made for designs mounted vertically than those appearing horizontally.

4. *What relative attention time is devoted to preferred and nonpreferred designs according to the judgment of the observers?*

[4] H. F. Brandt, Ocular patterns and their psychological implications Am. J. of Psych. Vol. 53, No. 2, April, 1940, pp. 260-268.

When subjects are requested to select one of two designs it is apparent that a certain attention time is required in order to make such a decision. But in addition it is necessary to obtain information relative to the attention time devoted to preferred and non-preferred designs.

Table V

Relative time spent by subjects on Preferred and Non-preferred designs.

Card No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Ave.
Designs Preferred	4.88	5.61	5.44	5.35	5.67	5.09	5.92	6.11	6.45	6.21	6.43	5.97	5.03	5.76	5.71
Designs Non Pref.	3.83	4.21	5.01	4.35	4.75	3.99	5.11	4.60	5.58	4.21	6.13	4.58	4.75	4.29	4.71

Based upon the results as tabulated in Table V subjects spend an average of 5.71 seconds on designs preferred while only 4.71 seconds is devoted to designs not preferred by the observer. This difference of attention time for the preferred and non-preferred designs of male and female observers is 5.51 to 4.43 and 5.90 to 4.98 respectively.

Table VI

Relative time spent on preferred and non-preferred designs

Design	M	σ	SEM	Md	SEdiff	C.R.
Preferred	159.76	13.55	3.76	28.00	5.74	4.88
Non-Pref.	131.76	16.68	4.63			

Not only is more time spent on designs selected than upon those rejected by the observer but in addition in a much larger number of choices is more time devoted to designs preferred. In only 11% of the total number of choices is more time devoted to the non-preferred than to the ones preferred.

5. *What relative attention time do subjects spend when observing cards in the order of sequence?*

As stated under the caption of procedure, cards were rotated in sequence so that each card appeared in every position of the series. The question which naturally arises is whether subjects spend more time on cards appearing earlier or later in the series.

Table VII

Relative attention time devoted by subjects when observing.
14 exposure cards in order of sequence.

Card Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Ave.
Male	7.29	5.20	5.98	5.52	4.48	4.73	5.27	4.85	4.15	4.91	3.98	4.66	4.21	4.18	4.97
Female	8.10	5.87	6.14	5.23	5.04	5.08	4.66	5.01	5.51	4.61	5.41	5.54	5.51	4.39	5.44

The correlation of attention time and the order of sequence is .805 when attention time of male and female is combined for each position. Figure 6 is a graphic representation of the diminishing attention time devoted to cards appearing later in the series. Male subjects show a greater attention time loss for suceeding exposure cards than do female observers.

6. *What relative attention time is devoted by subjects on designs when their selection agrees or disagrees with the choice of experts?*

Four hundred and sixty five (465) of the seven hundred and eighty four (784) choices of the subjects agree with that of the experts while three hundred and nineteen (319) disagree. Female subjects spend more time in making their selection but a larger number of their choices agree with those of the experts. Both male and female subjects spend significantly less time on designs when their choice agrees with that of the experts. This might imply that the human mind as evaluated by this analysis finds it less difficult to make a choice between two designs when selecting the one which according to experts conforms to fundamental principles of good art.

Table VIII

Attention time of subjects when choice agrees with experts

Subjects	Agrees with Experts		Disagrees with Experts	
	Frequency	Average Time	Frequency	Average Time
Male	223	2.78	169	7.86
Female	242	3.80	150	8.09
M & F	465	3.31	319	7.96

SUMMARY AND CONCLUSIONS

This study endeavors to discover by means of Ocular Photography a correspondence between the so called Laws of Color and Designs and Ocular Patterns. It is an attempt to evaluate the art object by scientifically testing the response of individuals to it. Based upon the response of individuals to the art object the author further proposes to provide a criterion for the verification of the adequacy or inadequacy of the observed field.

A number of ocular response patterns together with their psychological implications stand out clearly. One is that the female subjects as a group spend more time when selecting one of two designs. This increased attention time seems to be justified, however, since a larger number of their choices agree with those of experts.

A second phenomenon revealed by this technique is that significantly more time is spent on designs preferred by subjects as compared to designs rejected according to their own judgment. This conclusion seems logical due to the fact that human nature desires to retain or sustain what is satisfying and dispel or discontinue as soon as possible that which is dissatisfying. The neural hypothesis theory contends that the readiness of the nervous system determines for an individual the degree of satisfaction which accompanies such an act.

In computing the relative excursions made by subjects when observing designs mounted vertically or horizontally it is apparent that significantly more excursions are made when the eye is permitted to move laterally. This might imply that less aesthetical satisfaction accompanies an ocular performance when an excess of vertical eye movements is necessitated due to the character of the composition.

It is noteworthy that the attention of subjects observing respective exposure cards is consistently longer for cards presented earlier in the series than those observed later. This would imply that a ertain degree of fatigue or loss of interest operates. Cards seen first are accorded a longer observation time than those appearing later in the series. This is apparent especially for the first four cards of the series. The diminishing attention time for subsequent exposure cards is less pronounced for female than for male observers. Attention is diminished considerably when observing fourteen exposure cards but just how much attention time would be reduced by exposing additional cards can not be ascertained by the results of this study.

Another interesting discovery made by this study is that significantly less time is devoted to designs selected by the observer in agreement with those selected by experts.

Graves in his study designates designs preferred by artists. This study reveals that the average layman prefers a larger number of designs (465) in agreement with experts than those that are nonpreferred, (319) by such authorities.

Just why observers should devote less time to designs preferred by both the artist and layman is not clear at this time. The only possible explanation the author proposes is that the difference was sufficiently obvious that little time was required to arrive at a decision.

When speaking of the psychology of art we are no longer thinking in abstract terms when employing Ocular Photography as a Scientific Approach to the Study of Color and Composition. If the principle known as the golden mean with a ratio of 1.618:1.00 is considered more adequate than other proportions and if certain colors are positive, aggressive, relieving or tranquil and if balance, variety, dominance or unity seems to be inherent then it seems feasible that the unconscious reaction of the eyes is reflected in ocular patterns resulting. Based upon such implication it is likely that the behavior of the eye constitutes the final court of appeal in ascertaining the adequacy or inadequacy of a composition.

It is likely that original responses to color and composition are as natural as our response to salt and sugar. It is, however, expected that experience and association especially of the earlier years have a definite effect upon our response to the field of observation.

If this approach to the study of art will aid in a more adequate creation of it, we have much to expect from Ocular Photography as a technique in evaluating the why of color and design.

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REACTION TIME UNDER DIFFERENT STIMULUS CONDITIONS

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For military purposes it was desired to know the relation between two types of reaction time tests. These tests were: (1) a simple reaction time test of the usual type, (2) a "clock reaction time" test in which the subject attempted to stop the moving hand of a clock at a certain predesignated point on the face, by pressing a standard telegraph key. Seashore, Buxton, and McCollom (1940) have reported that certain factors corresponding to motor skills have been "isolated in terms of qualitative similarity in the *pattern of action*, including perceptual activity, involved in various tests rather than to anatomical units such as the dominant sense-field, or even the musculature employed." Seashore, Starmann, Kendall, and Helmick (1941) found that both simple and discriminative reaction times for visual and auditory stimuli are included in a group factor of speeds of single reactions. The same authors, however, warn against extending this factor to include other kinds of reaction time without experimental verification.

PURPOSE

It was therefore desired to determine the relation between simple visual reaction time, and reaction time when the subject watches the stimulus approach the given point at which he is to react.

PROCEDURE

Experimentation was conducted in a quiet room with the experimenter concealed from the subject. Subjects consisted of 40 college men, 7 CPT pilots, and 2 CPT instructors. For simple reaction time, the subject responded to a neon bulb flash, after a ready signal, by pressing a telegraph key. He was instructed to keep his attention on the response. In the "clock reaction time" the subject was instructed to watch the hand of a Standard Electric Time Clock, and to stop it at a given point by pressing a telegraph key. This point was changed so that there were four different positions at which the subject was instructed to stop the hand. He was given 10 trials for three of the positions, and 20 trials for one. Scores were in terms of the amount of error in stopping the hand. Fifty trials were given for both the simple and clock reaction times. The order in which subjects did each type of reaction time was alternated so that one subject did simple reaction time first and the next did the clock reaction time first.

To yield further information as to the method used by subjects in stopping the hand of the clock at a designated point, the CPT individuals were asked for introspections regarding their method of approach, as well as their feelings during the test. They were also rated by the two experimenters on such traits as assurance; tenseness; facial expressions; and on such methods as eye fixations; position of arm; arm, wrist, and finger movements; and smoothness of movement.

RESULTS

1. The product moment correlation between the two types of reaction time for 20 cases was $r = .37 \pm .13$. Doubling the number of cases (N=40), r was $.38 \pm .09$, indicating no need for the addition of cases.

2. Since every other subject took the simple reaction time first, any learning effects would have been cancelled. Had there been any consistent learning from simple reaction time to "clock reaction time" or vice versa, the correlation between these two might have been higher than that found. For this reason a group of 39 subjects was divided into two groups and a separate correlation figured for each. Group I of 21 cases had simple reaction time first. The correlation was found to be $rho = .31$ ($r = .33 \pm .14$). Group II of 18 cases had "clock reaction time" first. This correlation was $rho = .37$ ($r = .38 \pm .13$). Therefore, the correlation obtained with 40 cases was not lowered because of ignoring learning effects.

3. Introspective reports indicated a search on the part of the subject for a method of estimating when to respond, in the case of the clock reaction time. A few subjects hit on the method of watching the point at which the hand should be stopped instead of the hand itself, making use of peripheral as well as focal vision. Others tried to establish a point in advance of the stopping point in order to know when best to press the key. For this reason systematic introspections and ratings were made for 7 CPT students and 2 instructors. There was a tendency in this group of subjects for a lower percentage of error on the "clock reaction time" among those who fixated a spot a certain distance before

the designated stopping point, but this difference was not statistically significant as indicated by the t test. The same group who fixated the advanced point was consistently rated as more assured and confident than the other subjects.

4. The subjects reported feeling a difference in their approach to the two types of tests. This difference might be described as one of preparedness or set.

5. Further systematic ratings and introspections yielded no other differences.

CONCLUSIONS

1. The two types of reaction time have some elements in common as revealed by a correlation of almost $r = .40$. This might indicate that the "clock reaction time" is to some degree related to the group factor which includes simple reaction time.

2. There was enough difference in the two types of reaction time tests to be noticed by subjects, though in no consistent manner by them, and to keep the correlation low.

3. There is some indication that training in preparedness, on the "clock reaction time" test, in terms of anticipating the reaction might reduce the percentage of errors made.

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REACTION PATTERNS DURING A PERFORMANCE TEST

FRED KROEGER AND MACK T. HENDERSON

On previous experimentation with the Grinnell Eye-hand Co-ordination Test it was observed that each subject approached the test in a different manner. Could these things be observed during the test performance? If these observations could be made with reasonable accuracy, it would be likely that this technique would give us much needed information regarding the work habits and other personal characteristics of the person taking the test. With this purpose in mind it was decided to make some direct observations of persons taking the Grinnell Eye-hand Co-ordination Test. B. L. Travers (1941) in his article IMPROVING PRACTICAL TESTS, has also expressed the need for a procedure of direct observations which will show personal characteristics of subjects being tested.

APPARATUS

The subject is seated at a table (69 cm. x 107 cm.). Directly in front of him is an automobile steering wheel, with a horn button mounted in the center of the wheel. At his right is a standard gear shift lever; at his left is a hand brake. At the back of the table and facing S is a verticle screen (60 cm. x 92 cm.) containing sixteen irregularly spaced visual instructions. In many instances, these instructions are made to look like standard highway signs. Other printed instructions are included such as "shift to reverse", "horn", "shift to high." Each one of these visual stimuli may be illuminated by a six-volt bulb mounted directly behind the stimulus. S is asked to make the response suggested by the stimulus as soon as the sign is illuminated. A switch is mounted on the front right-hand part of the table so that S may start the experiment himself. By throwing this switch, the first stimulus is illuminated. When S makes the correct response to the first stimulus, the second visual instruction appears immediately. A correct response to the second stimulus provides the third instruction, etc. The last instruction of the series is "switch off". When S throws off the switch, the experiment is ended. The time elapsing from the beginning of the experiment to the end is measured in hundredths of a second (by a Standard Electric Precision Timer), and this time is regarded as a score for that trial. In other words, this apparatus measures serial reaction time. If S makes an incorrect response, he is penalized by the time factor only.

The apparatus has been kept simple in order that it may be used as a measure of eye-hand co-ordination for non-drivers as well as drivers. It has been found that little or no more time is required to instruct non-drivers in the apparatus than to instruct drivers.

PROCEDURE

Forty college girls were used as subjects in this experiment. Each girl took the Grinnell Eye-hand Co-ordination Test and then made several introspections regarding her reactions during the test performance. To aid the subject in her introspection, she was asked a standard list of questions. Some of these were: when during the test were you relaxed and when were you tense? Did you feel confused at any time during the test, and if so, when and why? What did you do and what did you think and feel while you were confused? How well do you think you did on the test?

All forty test performances were observed by one rater and twenty of these performances were rated by two. Immediately after the three trials, the observer or observers rated the subject by means of a graphic rating sheet on: amount of confidence; whether the subject's movements were rough or smooth; the amount of verbalization; whether she was calm or restless; whether she proceeded deliberately or impulsively. A check list to supplement the data of the rating sheet provided an opportunity to indicate whether or not the subject was cocky, profane, embarrassed, self-conscious, or confused.

The subject was instructed to work quickly but carefully because her score would depend on the amount of time it took her to complete the entire series.

She was told to begin the test by throwing the switch which illuminated the first instruction. The subject performed the test three times and after each trial she was given her score for that trial, as a subtle encouragement to do better.

RESULTS

The data show that the subjects could be differentiated on the basis of the rated observations and that the information recorded was specific. Both raters reported also that they felt it was not difficult to make judgments regarding individual reactions.

To check the reliability of the observations the ratings of both the observers were correlated by the Rank Difference method. For the twenty cases observed by two raters the correlations for the various traits ranged from .47 PE. .13 to .66 PE .09.

Table I—Correlations of the observations of the Two raters—by Rank-Difference Method

Trait observed	*Rho*	*P.E.*
Confidence	.66	.09
Smooth-Rough Movements	.59	.10
Calm-Excited	.48	.12
Deliberate-Impulsive	.47	.12

These correlations seem very high when compared with the Symonds' (p. 95, 1931) statement that "a reliability coefficient of .55 can be said to be typical for rating personality traits by ordinary judgment." These high correlations are particularly significant in the light of the fact that the raters had not discussed with each other the connotations of the terms on the rating sheet. These ratings might have been even higher if the raters had agreed upon specified definitions of the terms.

In the main, the introspective data did not yield much information of value. However, the two questions which yielded the most significant data were: "When were you tense and when were you relaxed?", and "How well do you think you did on the test?" The answers to the first question, "When were you tense and when were you relaxed?" very definitely showed methods of attack. For instance, when the question was answered, "I was tense during the first trial," it was revealed through further questioning that the subject felt uncertain in this new situation and became more relaxed with increased knowledge and familiarity with the apparatus. When the question was answered, "I felt relaxed during the first trial and I felt increasingly tense during the next two trials," further questioning revealed that the subject was trying to beat his former time.

Many of the subjects, in answering the second question, "How well do you think you did on the test?" said that they felt they had only done average work, while a few said that they had done "not so good" and some said they had done better than average. Often it was apparent to the observer that the people who answered that they had done only average or below average on the test were merely being modest, and that all of the answers showed certain personality traits. The answers to this question did not necessarily correspond to the test scores.

The test score averages showed that there was a difference between those who were rated as proceeding calmly and smoothly and those who reacted in a jerky and impulsive manner, but this difference was so slight that it was decided that even though the scores have not as yet been submitted to statistical treatment, the differences in the averages are probably insignificant.

The same could be said for the score averages of those who approach the test in a confident manner and those who felt unsure of themselves.

Perhaps averages are not as important as it would seem. It is probably more important to state how the subject proceeded, no matter what his score. This would imply that information of this type should be individualized. For instance, many of the girls who made the fastest scores, reacted impulsively and made rough movements, yet just as many fast scores were made by those who reacted calmly and smoothly. Also the ratings showed that slow scores were made by the same methods that were used to make fast scores. Many times girls who reacted impulsively and roughly became excited and made mistakes, making their scores as slow as those who proceeded very calmly and deliberately.

CONCLUSIONS

1. The data indicate that the reactions of an individual in a test performance can be observed with reasonable accuracy.

2. The graphic rating scale is a convenient method of recording these observations for the scale yields specific as well as reliable information.

3. It is felt that these observations can be useful as supplementary data because many times the test score does not indicate enough about the subject. Some subjects may proceed calmly and deliberately and some may proceed in an erratic and impulsive fashion, yet in spite of this get the same score.

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INFLUENCE OF DEGREE OF ORIGINAL LEARNING UPON ASSOCIATIVE AND REPRODUCTIVE INHIBITION

FRANKLIN J. SHAW

INTRODUCTION

Although the experimental literature on retroactive inhibition is vast, the only previous systematic study using verbal material of retroactive or reproductive inhibition as a function of degree of original learning is one by McGeoch (McGeoch, 1929). He found that relative amounts of retroactive inhibition varied inversely as the number of presentations given the material to be learned. The present study differs from McGeoch's primarily in that paired-associates, rather than serial lists, were learned. Since information on reproductive as well as associative inhibition as a function of degree of original learning would seem essential to the formulation of a precise theory of retroactive inhibition, the present study, using paired-associates, has been conducted to see if the same trends are present as are found with serial lists in the investigation of retroactive inhibition.

PROCEDURE

Four different degrees of original learning were used in this experiment. They were 2 repetitions of the original list, 5 repetitions, 10 repetitions, and 20 repetitions. The interpolated learning was always for 5 repetitions.

The subjects learned lists of paired-associates on a modified Hull drum. Five different orders of presentation of each list of 10 pairs of two-syllable adjectives were used. The subject's task was to anticipate the second member when the first member appeared. Each pair in the interpolated list had as its first member a word which appeared as the first member of a pair in the original list.

Before he began the experiment proper, each subject had two days of practice on each of which he learned two lists.

One group of 12 subjects worked under the conditions required to measure the influence of 5 and 10 repetitions of the original list and another group of 12 under the conditions required to measure the influence of 2 and 20 repetitions of the original list.

The interval between original learning and relearning was 20 minutes. The intervals during the rest conditions were filled with looking at cartoons. The portion of the interval not taken by interpolated learning during the work conditions was also filled by looking at cartoons.

A total of 30 repetitions, exclusive of the trials required to relearn the original lists was given under each condition. The purpose of this was to distribute degree of learning over the conditions to as nearly an equal average degree as possible.

A scheme whereby conditions were counterbalanced was used throughout the experiment.

RESULTS

The results on associative inhibition can be summarized briefly, since none was found that could be considered in any way signifigant. The exact results on associative inhibition are presented in Table I. It is apparent from an examination of the table that percents of associative inhibition are not only small, but that critical ratios for the differences between original and interpolated learning are by no means signifigant. The only direct comparison that can be made with serial learning derives from a study by Melton and Irwin (Melton and Irwin, 1940). They found that with 5 degrees of original learning and 5 degrees of interpolated learning, as were present in one condition in the present study, associative inhibition was 42.2%. This result at least approached signifigance, since the critical ratio for the difference between original and interpolated learning was 2.79. This differs sharply from the result for the same condition in the present study in which the associative inhibition was only 7% with a critical ratio of only .32 for the difference between original and interpolated learning. If the same discrepancy in associative inhibition between serial learning and paired-associate learning should hold for all degrees of original learning, it might be concluded that serial position was a necessary condition of

Table I. Amount of Associative Inhibition with Different Degrees of Original Learning

Degree of Original Learning	Amount of Associative Inhibition	Critical Ratios for differences between original and interpolated learning
2	6%	.30
5	7%	.32
10	-6%	.50
20	9%	.68

associative inhibition, since serial position remains the same with serial learning whereas it does not with paired-associate learning.

The results on retroactive or reproductive inhibition in terms of mean number of correct anticipations are shown in Tables II, III, and IV. An examination of these tables reveals that there is a general tendency for retroactive inhibition to dissipate after the first relearning trial. Although there is a noticeable rise in retroactive inhibition from relearning trials 1 to 2 in the condition in which there were 2 degrees of original learning, this can be attributed to chance.

McGeoch found with serial lists that retroactive inhibition when measured in terms of correct anticipations varied inversely with degree of original learning (McGeoch, 1929). With the exception of the condition in which there were 2 degrees of original learning, these results correspond with his. If McGeoch had had a condition with this low a degree of original learning, his results for

Table II. Retroactive Inhibition in terms of Mean No. of Correct Anticipations on First Relearning Trial

Degree of Original Learning	Retroactive Inhibition	Critical Ratios for differences between relearning after rest and after work.
2	0%	0
5	50%	3.7
10	23%	3.1
20	15%	2.16

Table III. Retroactive Inhibition in terms of Mean No. of Correct Anticipations on Second Relearning Trial

Degree of Original Learning	Retroactive Inhibition	Critical Ratios for differences between relearning after rest and after work.
2	17%	.75
5	19%	1.9
10	10%	1.7
20	5%	1.11

Table IV. Retroactive Inhibition in terms of Mean No. of Correct Anticipations on Third Relearning Trial

Degree of Original Learning	Retroactive Inhibition	Critical Ratios for differences between relearning after rest and after work.
2	-2%	.10
5	1%	.14
10	11%	1.54
20	2%	.36

retroactive inhibition with this condition would probably have corresponded with the result reported here.

The percentage of retroactive inhibition in terms of trials required for relearning was relatively high for all conditions except that in which there were 2 degrees of original learning. The correspondence between retroactive inhibition in terms of correct anticipations and relearning trials was not close, however. Since a definite tendency toward dissipation of retroactive inhibition in terms of correct anticipations was shown, it seems unlikely that relearning scores which showed high amounts of retroactive inhibition would be reliable. That they were unreliable is substantiated by the fact that the critical ratios for the differences between rest and work conditions in terms of trials required for relearning were consistently small.

The overt intrusions corresponded more or less closely with the retroactive inhibition for the various conditions as is shown in Table V. Omitting the condition in which there were 2 degrees of original learning, both retroactive inhibition and overt intrusions vary inversely with degrees of original learning. An incidental finding of interest was that overt intrusions often appeared late in the learning of a balance list which might be taken as evidence for the very real existence of implicit competition between responses.

Table V. Overt Intrusions and Retroactive Inhibition for the Different Degrees of Original Learning

Degree of Original Learning	Overt Intrusions	Retroactive Inhibition
2	4	0%
5	15	50%
10	9	23%
20	8	15%

SUMMARY

The experiment was designed to determine the influence of degree of original learning upon associative and reproductive inhibition. The degrees of original learning were 2, 5, 10, and 20. Interpolated learning was always for 5 repetitions. The findings were as follows:

1. No associative inhibition which could be considered signifigant in any way was found. This differs from results found with serial lists. Paired-associates were used in this experiment.

2. With the exception of the condition in which there were 2 degrees of original learning, retroactive or reproductive inhibition varied inversely with degree of original learning. This corresponds with results found with serial lists.
3. A rough correspondence between overt intrusions and retroactive inhibition was found with the exception of the condition in which there were 2 degrees of original learning.

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THE PREDICTION OF DRIVING ABILITY FROM LABORATORY MEASURES AND EXPERIENCE INDICES FROM A SYSTEMATIZED INTERVIEW

LEONARD E. SHUPE AND A. R. LAUER

THE PROBLEM

The U. S. Army is faced with the problem of selecting drivers for immediate and active service in the motorized units. Although the youth of America are mechanically inclined, intimate acquaintance with the operation and care of motor vehicles is not at all universal. Many have driven but slightly, and usually have had experience with passenger type vehicles only.

It is unfortunate that the information and skill about driving and the potential power of motor vehicles is too frequently picked up incidentally. As a result, far too many accidents occur in civilian driving. The age of the average man in the army ranks parallels closely that of the highest accident group in the total population. This seems to be due to two factors: (1) enough experience to give a degree of confidence, but, (2) not enough to inculcate the inherent dangers involved in driving. As a result, much unnecessary loss in man power and materials is occasioned by unscientific selection and training of personnel.

The army faces a double problem. First, there is that of taking a given personnel and getting equipment moved immediately. This will be referred to later as present ability. The second is that of training a given personnel to a high level of efficiency for combat and transport purposes. This is referred to in the article as potential ability. These two may or may not overlap and the purpose of the present study is to determine the extent of certain components of each type of ability and the possibility of selecting personnel from a given set of data obtained from the soldier's record, by interview and from certain specific tests which can be quickly administered. Time will not permit amplification of details on the tests, but it suffices to say that they covered intelligence, knowledge of motor vehicles and principles of safe manipulation, experience, actual manipulation of a command car and certain psycho-physical laboratory tests to ascertain fitness for operation of a motor vehicle.

METHOD AND PROCEDURE

These data were composited into the following scores for purposes of analysis:

Alertness—an abbreviated intelligence test having a reliability of .85.

Compensation—a pencil and paper test of the degree to which a driver tends to offset his weaknesses. The reliability of this test was found to be about .70.

Knowledge—a test of knowledge of driving and efficient motor car operation.

Present ability—a composite score based on experience, actual performance at the wheel and certain characteristics of immediate importance to driving such as visual acuity, distance judgment and strength.

Potential ability—a composite score based on psych-physical tests necessary to the proper control of a motor vehicle.

RESULTS

Coefficients of correlations between the various tests showed a great deal of variation, for example; with actual and potential scores, r equals .437; with knowledge and present ability, or actual scores, r equals .315; when intelligence and potential scores were correlated, r equaled .303; with intelligence and compensation, r equaled -.017; and in the correlation of intelligence with knowledge of driving practices the coefficient was found to be .689.

TABLE I

Correlations

Variable	1	2	3	4	5
1. Alertness	.. ..	-.017	.689	.176	.303
2. Compensation	-.017	.. ..	.053	.059	.271
3. Knowledge	.689	.053	.. ..	.315	.190
4. Actual	.176	.059	.315	.... ..	.437
5. Potential	.303	.271	.190	.437	....

The Pearson product-moment coefficient of correlation was computed by the deviation method.

An examination of the standard errors of these coefficients of correlation, reveals that some of the differences and resemblances may be attributed to errors of sampling. However, in the case of the correlation between intelligence and knowledge, the result is statistically significant, since the coefficient of .689 has a standard error of only .065. This coefficient is well above three times the standard error. The coefficient of correlation between present and potential ability scores also shows statistical significance.

Table Ia Standard Errors of r

Variables	-	2	3	4	5
1. Alertness	...	.124	.065	.120	.113
2. Compensation	.124	...	.123	.124	.115
3. Knowledge	.065	.123	...	.112	.120
4. Actual	.120	.124	.112	...	.100
5. Potential	.113	.115	.120	.100	...

In order to utilize other measures of relationships present among these various tests of driving ability, partial correlations were computed. These calculations show from no relationship between knowledge and potential scores when intelligence is held constant, to the relatively high value of .689 when intelligence and knowledge were correlated with compensation held constant. Other values were found as follows: .409 between actual, or present ability scores, and potential, with intelligence held constant; .436 when present ability and potential scores were correlated with present ability scores held constant; .679 when intelligence and knowledge were correlated with present ability scores held constant; and .674 when intelligence and present ability scores were used with potential scores held constant.

Table II Partial order correlations of the first order
Variables: 1. Alertness; 2. Compensation; 3. Knowledge;
4. Actual; 5. Potential.

r12.3 = –.075
r14.3 = –.061
r15.3 = .242
r24.3 = .044
r25.3 = .266
r45.3 = .404

r23.1 = .090
r24.1 = .063
r25.1 = .290
r35.1 = –.028
r45.1 = .409
r13.2 = .689

r14.2 = .175
r15.2 = .310
r34.2 = .313
r35.2 = .183
r45.2 = .436
r12.4 = –.029

r13.4 = .679
r15.4 = .255
r23.4 = .036
r25.4 = .261
r35.4 = .073
r12.5 = –.104

r13.5 = .674
r14.5 = .051
r23.5 = .002
r24.5 = .068
r34.5 = .263

Partial correlations of the second order produced a value of .434 when present ability and potential scores were used as variables while intelligence and knowledge were held constant. A value of .409 was obtained when variables, present ability and potential ability were used with intelligence and compensation held constant. Correlation of present ability and potential ability yielded .406 when compensation and knowledge were held constant.

Table IIa Partial order correlations of the second order
Variables: 1. Alertness; 2. Compensation; 3. Knowledge;
4. Actual; 5. Potential

r14.23 = –.061 r34.12 = .267 r45.23 = .406
r23.13 = .049 r45.12 = .409 r15.23 = .252
r35.12 = –.066 r45.13 = .434 r25.13 = .286

Partial correlations of the third order gave the value .441 when present ability and potential ability scores were correlated with intelligence, compensation, and knowledge held constant.

Table IIb Partial order correlations of the third order
Variables: 1. Alertness; 2. Compensation; 3. Knowledge;
4. Actual; 5 Potential.

r41.235 = –.185 r42.135 = –.087 r43.125 = .318 r45.123 = .441

Table III

The coefficient of multiple correlation was found, using it to estimate the success of the actual or present driving ability of a person from the known characteristics of intelligence, knowledge, compensation and potential driving ability. This coefficient was .527.

Table III Multiple correlation
Variables: 1. Alertness; 2. Compensation; 3. Knowledge;
4. Actual; 5. Potential.

R4(1235) .527

Table IV

In order to predict the scores a driver might make on the actual test, a formula was obtained for the prediction, by developing a multiple regression equation. The equation thus developed was Y equals .568X plus 32.3, where Y was the present ability scores and X the potential scores.

A second multiple regression equation gave the formula Y equals .201Z plus .507X plus 2.8, where Y was the present ability score, Z the knowledge score and X the potential score.

Correlations between other tests were computed, but these given here represent the major results of the study.

Table IV. Multiple regression equations to predict actual scores from potential scores.
Variables: Z equals knowledge; X equals potential;
Y equals actual, or present ability scores.

Y equals .568X plus 32.3 or Y equals .291Z plus .507X plus 2.8

CONCLUSIONS

From zero order and multiple correlation of scores, based on sixty-five cases, the following summary is made, and it seems that the following tentative conclusions may be drawn:

1. The highest correlation obtained was .689 between intelligence and knowledge of motor vehicles. This might be expected both from the experience factor and the power of observation.
2. The correlation between potential and present ability scores was .437, indicating considerable association; but possibly two separate categories of measured traits or characteristics.
3. Intelligence or alertness is a more important factor in selecting *potential ability* groups than in selecting *present ability* groups.
4. Knowledge is much more important as a factor in selecting *present ability* personnel.
5. Compensation is unrelated to intelligence but seems to be an important factor in selecting *potential ability* groups. It has been a neglected factor in all aptitude testing.
6. In general it *seems that quickly administered tests,* when used in conjunction with the experience record, would be quite valuable in selecting personnel both for present as well as *potential ability* to operate a motor vehicle.

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THREE COMPARISONS OF RETROACTIVE AND PROACTIVE INHIBITION

Benton J. Underwood*

Retroactive inhibition (RI) has long been recognized as one of the most potent factors in forgetting. Of relative recent treatment is the forgetting produced by the operations defining proactive inhibition (PI). If RI is defined as a decrement in the recall of an activity as a result of other activity *intervening* between the original learning and recall, PI may be defined as a decrement in recall as a consequence of an activity which took place *prior* to the original learning.

Before a precise formulation of a theory of forgetting is attainable, or before an adequate mathematical expression of the conditions of forgetting can be derived, it is necessary to make extensive comparisons of factors which cause variations in RI and PI. By such experimentation it may be possible to discover the convergent or divergent mechanisms which underlie the forgetting produced by these two types of inhibition.

It has been shown (Melton, A. W. & von Lackum, W. J., 1941) that with serially learned nonsense syllables RI is significantly greater than PI. It seemed desirable to extend their experiment by using adjectives learned as paired associates but keeping intact their basic experimental design. The present paper is a report of a series of experiments in which this has been done. In short, will RI always be greater than PI under comparable conditions?

Methods and Materials

Three experiments have been performed with each experiment inculcating within its design the control and experimental conditions necessary for yielding measures of RI and PI. Except for minor variations, the design duplicates that used in the experiment cited above (Melton, A. W. & von Lackum, W. J., 1941).

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* This research was under direction of the late Dr. John A. McGeoch. Experiment C, reported here, was in progress at the time of his death.

TABLE I

Sequence of Events in Experimental Conditions Designed to Measure Retroactive and Proactive Inhibition

Condition	*Original Learning*	*Rest or Interpolated Learning*	*Relearning*
I (RI Control)	A-B	30′	A-B
II (RI Work)	A-B (1′) A-K		A-B
III (PI Work)	A-B (1′) A-K		A-K
IV (PI Control)	A-K		A-K

Table I is a schematic outline of the 4 experimental conditions. Conditions I and II are the control and experimental conditions respectively for measuring RI, and conditions IV and III are comparable conditions for the measurement of PI. A-B represents a pair of two-syllable adjectives symbolic of the original learning, with A-K the interpolated learning in which the old stimulus is paired with a new response. Ten pairs of adjectives made up each list used.

The pairs were presented at a 4 sec. rate on a modified Hull memory drum. For each of the 3 experiments, 24 subjects were used. This allows for a complete counterbalancing of conditions so that unknown differential effects of any list are not specific to any conditions. Before the 4 experimental sessions started, each subject went through 2 practice sessions to familiarize them with the procedures used. Thus, each subject served approximately 6 hours. All rest periods were filled with the ranking (for humor) of mounted cartoons.

The basic design shown in Table I was used with the specific conditions of the three experiments varying as follows:

Experiment A. The subjects were graduate students in psychology. The adjectives were presented in constantly changing order with the criterion of original and interpolated learning being 6 correct responses on 1 trial.

Experiment B. The subjects were undergraduates. The pairs were presented in constantly changing order, but the criterion or original and interpolated learning was *6* trials.

Experiment C. Here again, the subjects were undergraduates, but the adjectives were presented in a *constant* order for each trial. The original and interpolated learning was for 4 trials.

The degree of original learning in the 3 experiments was approximately the same, despite the varying criteria used. The mean of the 4 original learnings for experiment A was 6.65, for B, 5.50, and for C, 5.74.

RESULTS

The most reliable measures of inhibition are the recall scores. Table II shows the mean number of correct responses on each of the 4 conditions of the 3 experiments of the first relearning trial. The experimental design outlined above allows for a direct comparison of the recall scores of the PI and RI work conditions after it is shown that the recall on the two control conditions (I and IV) do not vary significantly by virtue of the small time differences existing between original learning and recall. Table II indicates that the recall differences on these conditions may be considered as being chance differences. In experiment C the difference is in the opposite direction from that which might be expected by the shorter time interval of condition IV. The sigma values are given after each mean.

TABLE II

Amounts of RI and PI as Measured by the Mean Number of Correct Anticipations on the First Relearning Trial

Conditions	I	II	III	IV
Exp. A	4.08(.28)	2.17(.30)	2.71(.30)	4.54(.42)
Exp. B	4.54(.50)	2.50(.36)	3.25(.45)	4.79(.55)
Exp. C	3.71(.53)	1.71(.39)	2.54(.35)	3.33(.46)

In experiments A and B, significant amounts of RI and PI are found on the first relearning trial (*t*'s = 5.65 and 3.81, respectively for Exp. A, and 5.23 and 3.21 for Exp. B). In experiment C, however, no significant amount of PI is found, although the difference between the work and rest conditions is in the expected direction. The mean difference is .79, with a *t* value of 1.44. On the other hand, the mean difference between the RI work and PI conditions is 0.83 (t=1.73); in experiment B the difference is .75 (t=2.03); and in experiment A the difference is .54 (t=2.00). While all of these differences are statistically insignificant they are consistent with the finding previously reported (Melton, A. W. & von Lackum, W. J., 1941) with serial learning. What is left to be explained is why in serial learning the differences should be greater than in paired associates learning; this in spite of the fact that experiment C was set up to enhance serial learning of paired associates, since the adjectives were presented in a constant order and many of the subjects reported they learned the adjectives serially, at least in the initial and final portions of the lists.

Table III shows the percent of inhibition for the three experiments during the first three relearning trials. The percentages for the first relearning trial supplement the absolute decrements shown in Table II. Additional evidences for the greater influence of RI is shown by the more rapid dissipation of PI. Shown also is the greater transitoriness of the inhibition in experiment C as compared with experiments A and B.

TABLE III

RI and PI as Measured by Percent of Inhibition on the First Three Relearning Trials for Experiments A, B, and C

	Exp. A		Exp. B		Exp. C	
	RI	PI	RI	PI	RI	PI
Trial No. 1	47%	40%	45%	32%	54%	25%
Trial No. 2	31%	16%	25%	10%	12%	–5%
Trial No. 3	16%	11%	10%	4%	9%	–4%

The data so far shown seem to indicate that RI is greater than PI, though the differences are small. We have one further measure of the inhibition which is corroborative evidence of these consistent though small differences. During the relearning of the original list (Condition II) or relearning of the interpolated list (Condition III), responses are made which are inappropriate for the list being learned, i.e., they are overt intrusions either from the original learning in PI, or from the interpolated learning in RI. Such intrusions are the most direct evidence available to support a competition theory of PI and RI (McKinney, F. & McGeoch, J. A., 1935, and Melton, A. W. & McQueen-Irwin, J., 1940). Table IV shows the frequency and locus of these intrusions as they occurred in the present experiments. More than cursory interest should be attached to these phenomena since a comparison of the frequency of these intrusions with the percent of inhibition shown in Table III shows a striking correlation, and this in spite of the fact that the gross frequency of intrusions is relatively small, being less than one per subject at the point of maximal inhibition. No particular importance should be attach-

TABLE IV

The Frequency and Locus of Overt Intrusions on the PI and RI Conditions of Experiments A, B, and C

	Exp. A		Exp. B		Exp. C	
	RI	PI	RI	PI	RI	PI
RL Trial No. 1	19	16	16	9	13	5
RL Trial No. 2	12	2	3	4	4	0
RL Trial No. 3	5	2	3	1	1	1
Remainder	20	4	6	1	2	0

ed to intrusions which occurred in experiment A after the first three relearning trials. This sum, 20 overt intrusions, is a result of perseveration of errors for three subjects and is not typical of the learning of most subjects.

Any conclusions that can be drawn as to differences between RI and PI under the conditions reported in these experiments are contingent upon the acceptance of consistent small differences as true differences. The reason for placing some confidence in these differences is based upon a prior experiment with serial learning in which considerably larger and significant differences were found. The data on overt intrusions that have been presented also tend to support a conclusion of the greater potency of RI over PI. However, whether these differences are true differences or not, it appears that one important condition determining variations in PI and RI is the method of learning, i.e., serially or by the paired associates technique used here. Nevertheless, it is not clear from these experiments why or how these inhibitions diverge as a function of the mode of learning.

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CHANGES IN THE ATTITUDES OF COLLEGE STUDENTS IN RELIGION AND POLITICS

George R. Pullman and Earle E. Emme

PURPOSE: It is the purpose of this paper to determine whether or not the attitudes of college students change in the fields of Religion and Politics as a result of having taken courses pertaining thereto or as a result of the college experience as a whole.

SOURCES OF INFORMATION: Information was obtained through a summarization of research on the subject and by an investigation of recent psychological magazines and bulletins.

CHARACTERISTIC ATTITUDES OF STUDENTS BEFORE ENTERING COLLEGE.

Children tend to imitate and become like their parents and other associates, taking over the culture of the group because they see a resemblance between themselves and others (Murphy, Gardner, Newcomb, 1937, p. 189). Adolescence is a crystallization of attitudes toward the larger world—attitudes toward sex, race, religion, economics, and social status; differences in attitudes toward institutions such as the school, the family, church, clubs, etc.; and identification with the morality of the group or deviation from it (Murphy, Gardner, Newcomb, 1937, p. 619). Many changes, therefore, are brought about by mere age or maturation (Murphy, Gardner, Newcomb, 1937, p. 919).

Belief is closely associated with desire. When asked to rate the relative importance of seven factors which influenced "the average college student" in arriving at his opinions and to rate the same factors as to the influence upon their own opinions—most subjects regarded their fellows as being swayed more by "teaching and training" than they themselves were, but themselves as influenced more by "personal reasoning" and "personal experience." Such evidence further betrays the intimacy of emotion and belief; and further assures us that certainty of opinion is a function not of information, but of desire (Murphy, Gardner, Newcomb, 1937, p. 940).

Occupational trend has a definite relationship to the attitudes of college students (Duffy, 1940, p. 608). Evaluative attitudes are definitely, though perhaps not closely, related to academic achievement (Duffy, 1940, p. 609). Student vocational choice seems to be more closely related to social, moral, and religious attitudes than is the time spent in college (Nelson, 1940, p. 282).

Fraternities and the ROTC also have decided influence upon the attitudes of their members (Murphy, Gardner, Newcomb, 1937, pp. 989, 990).

PROCEDURE FOR TESTING.

The procedure of testing for attitude changes in connection with educational institutions requires that the subjects be tested simultaneously at different educational levels. This procedure is completely valid only upon the assumption that the to-be-compared educational levels are within the same community, and that the sampling at one level is as representative as at another. One is often left wondering whether attitude changes coincident with a given period of education are not simply the consequences of additional months or years of living in a particular cultural environment rather than the results of the school experience itself (Murphy, Gardner, Newcomb, 1937, p. 978). Study can also be made by analyzing the educational backgrounds of groups selected on the basis of present attitudes (Murphy, Gardner, Newcomb, 1937, p. 987).

ATTITUDE CHANGES IN RELIGION.

The most religious attitudes are found among students who have chosen the ministry, home-making, medicine, music, and teaching. The less religious attitudes are found among those choosing aviation, journalism, law, and commerce. Students choosing the ministry are most favorable toward the institution attended (Nelson, 1940, pp. 279-282). In a study made of students working part time in college, the N.Y.A. records show that the aid group are more favorable toward Sunday observance (Nelson, 1940, p. 361). Research findings also indicate that women possess more favorable attitudes toward Sunday observance, the church, the reality of God, and God as an influence on conduct (Murphy, Gardner, Newcomb, 1937, pp. 915-916, and Nelson, 1940, pp. 325-423).

Small but consistent differences occur between the Freshman and Senior years in college. Seniors accept fewer conservative moral and religious beliefs, believe fewer superstitions and more in evolution (Murphy, Gardner, Newcomb, 1937, p. 983). Freshmen show more contradictions than seniors. Seniors tend to be more liberal. In a recent study, 79 subjects state they have less religious faith at the time of the study than they did when they entered college, 49 report more. The former group was found to be slightly less conservative on the Harper Test (Murphy, Gardner, Newcomb, 1937, p. 983). Upperclassmen show reliably less belief in a personal God and prayer, more in an impersonal God than underclassmen. They are also more critical of the church and of institutional practices than when they entered college, but little change is noted in the need for religion or interest in the church. The majority maintain the same belief as when entering college (Murphy, Gardner, Newcomb, 1937, p. 985).

Five-step attitude tests were administered before and after the speeches of four speakers at the Young People's Religious Union (Unitarian) summer conference. Shifts were studied by a technique based on that of Murphy and Likert: The number of actual shifts was divided by the number of possible shifts in a given direction and the fraction thus obtained was subtracted from a similarly obtained fraction based upon actual and possible shift. A result of .00 would indicate complete change. Changes on neutral questions produced by the four speakers were, respectively, .11, .45, .26, and .19. The results are further analyzed in terms of the speaking ability of the lecturers and the extent to which their subject matter agreed or disagreed with the formulated beliefs of the audience. The relatively small amount of change is stressed in the conclusions. It is felt that the content of the questions where great changes were produced is of primary importance. A speaker in whom the audience has confidence easily produces changes where the previous opinions are not emotionally toned or dogmatic. However, the utility of statistical analysis is questioned and the use of opinion-auto-biographies to correlate with such analysis is urged (Dexter, 1939, pp. 76-83).

Orthodox students are the most likely, and the liberal theists and atheists least likely to change in their religious attitudes as a result of the college experience (Murphy, Gardner, Newcomb, 1937, p. 985). The amount of religious training bore little relationship to present interest or belief. There is a discrepancy between belief and practice (Murphy, Gardner, Newcomb, 1937, p. 1002). Religious attitudes also tend to characterize other attitudes (Murphy, Gardner, Newcomb, 1937, p. 1002).

ATTITUDE CHANGES IN POLITICS.

There is a trend toward liberalism, as a general rule, at the college level with effects being more pronounced among students from rural and small-town backgrounds and among those enrolled in social science courses (Murphy, Gardner, Newcomb, 1937, p. 981, and Garrison, 1938, pp. 490-494).

Good students have higher theoretical scores and lower political value scores than poor students (Duffy, 1940, p. 601).

Students who have chosen as their vocation: banking, dentistry, music, and government service are conservative, whereas more liberal attitudes are found among those planning on journalism, social work, law, and agriculture (Nelson, 1940, pp. 279-282). History groups were found to have the most interest in politics while the household arts and nursing groups were found to be least favorable toward it (Murphy, Gardner, Newcomb, 1937, pp. 985, 988). A year's course in American History gave reliable changes in classes where the teacher was aware of the experiment (Murphy, Gardner, Newcomb, 1937, p. 951).

Student attitudes change in the direction of propaganda heard. Such changes have been found to be reliable by all groups HEARING speeches, and by most groups reading them; but little difference exists between "emotional" and "rational" appeals (Murphy, Gardner, Newcomb, 1937, p. 957). Students also showed little change on remote items (Murphy, Gardner, Newcomb, 1937, p. 959). In a recent experiment, regarding the propagandizing of students on political affairs, the emotional appeals were far more effective than the non-emotional. The totals for all groups showed a tendency to accept stereotyped statements from both sides (Menefee, 1940, pp. 393-404). Oral presentation is found to be more effective than written (Murphy, Gardner, Newcomb, 1937, p. 965).

Topics which showed the greatest absolute amount of change in courses of Sociology are questions of fact. Responses closely tied up with emotion and prejudices (conservatism in general, anti-socialist and anti-labor sentiment, and race prejudice) changed drastically when full discussion was allowed (Menefee, 1938, pp. 545-556).

In 1936, students' political preference in the presidential election was studied in relationship to many other factors. It correlated highest with national and local political sympathies, father's preference in 1936, and attitudes toward the New Deal, in lesser degree with many other factors; and hardly at all with attitudes toward morality, newspapers read, class in college, and father's occupation (Fay, 1940, pp. 107-119) (Young and Oberdorfer, 1938, pp. 442-456). Subjects were also tested when they recorded their favorable or unfavorable attitudes toward a number of terms such as Uncle Sam, Labor, and the New Deal, then reacted to cartoon caricatures of the same subject matter. Significant shifts in attitude generally occurred with strongly complimentary or uncomplimentary cartoons of subjects about which the group opinion was neutral or divided (Asher, and Sargent, 1939, p. 638). Motion pictures effect changes. However, there is little change on remote items (Murphy, Gardner, Newcomb, 1937, p. 957).

Under the conditions of another recent experiment, the attitude of male college students toward communism, the U. S. Constitution, law and censorship was studied and found to be more liberal than that of the female students. Among the findings were: a consistent trend toward liberalism from freshman to senior year, less tolerance among fraternity members and pledges toward communism than among unorganized students (Murphy, Gardner, Newcomb, 1937, p. 983; Fay, 1939, pp. 378-390).

A modification of Vetter's social and political attitudes test was given to 52 freshmen, 18 sophomores, 36 juniors, and 64 seniors at North Carolina State College. The results reveal higher scores for the seniors, indicating the possession of a more liberal attitude (Garrison, 1938, pp. 490-494). There are sex differences, but they vary with economic status (Murphy, Gardner, Newcomb, 1937, p. 917).

One hundred-forty four Freshmen students of the University of Louisville were given interest and belief tests before and after they had taken a social science survey course. The tests given following the course showed that with respect to war and negroes, the students became more liberal. They were more favorable toward democracy and opposed imprisonment of Nazi and Fascist organizers. In 20 out of 26 comparisons dealing with specific attitudes or beliefs the scores were more uniform on the second than on the first test (Whisler, 1940, pp. 387-396).

A freshman class in a course in American Institutions, consisting of 565 men and women, showed, at the opening of the semester, general attitudes opposed to much change in the present standards of government. A second administration of the questionnaire at the end of the semester, showed some shift of opinion on all questions, and, with the exception of two questions relating to the Supreme Court, the shifts were all in the direction of a favorable change (Fitch and Remmers, 1941, pp. 187-194).

CONCLUSIONS.

The following conclusions are suggested as a result of the study:

1. Reliable changes in attitudes are brought about generally in the direction of liberalism accompanied by the college experience.

2. Teachers effect changes more directly than do the courses themselves.

3. Oral presentation is more effective than written.

4. Students show a more reliable change in attitude with questions based on facts rather than emotion.

5. Although the attitudes of college students do not change appreciably in the fields of Religion and Politics as a result of their college experience, such courses are deemed valuable in that they encourage students to think for themselves—thereby gaining an understanding of the attitudes that they possess.

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FINDINGS FOR A PSYCHOLOGY OF RELIGION

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I. THE SITUATION

1. A recent analysis of the nine most recent textbooks on the Psychology of Religion revealed a dearth of the commonly accepted findings in the field of psychology. Early authors omit topics of *personality, mental health, personal religion,* and *religious expression. Childhood* and *adolescence* were discussed in a minor way. Much emphasis was given to mysticism, immortality, primitive religions, prayer and other topics of considerable interest to theologians. The needs and interests of children, adolescents, and adults are readily recognized as basic to any adapted psychology of religion. Likewise, ideals, character values, methods of influencing youth, etc., should be rated as very important by phychologists.

2. It was assumed that modern psychological findings have much to contribute to a valid psychology of religion.

II. PURPOSE OF THE STUDY.

To discover psychological research findings which have bearing upon a psychology of religion. Because of time limitation the findings are only reported on *ideals, character, children, adolescents,* and *adults.*

III. METHOD OF PROCEDURE

1. Phychological abstracts for the past eight years were investigated.
2. Psychological findings in recent textbooks of psychology of religion were surveyed.
3. A recent study of the nine commonly used textbooks in this field was evaluated.
4. Psychological and religious journals were surveyed for findings.

IV. RESEARCH FINDINGS.

I. IDEALS.

Religious institutions quite generally use the direct method of seeking to inculate the ideals they consider more important. The noted Character Inquiry, directed by Hartshorne and May, gives many findings to refute the adequacy of such a procedure. Likewise, that the method and degree of enjoyment of the process is far more important than the objective desired.

A few of these major findings are:

1. Learning, to be effective, must be experienced. (Hartshorne, H. and May, Mark, 1929).
2. The desired experience must be represented in the normal situation to which individuals are exposed.
3. The situations made for the individual in learning must be opportunities to pursue interests which lead to the desired conduct to be learned.
4. The Conduct to be learned must be carried on in relation to the particular situations which develop the preferred mode of response.
5. The established practice and code of a group colors any situation and may either hinder or assist the acquisition of desirable individual and group responses. (Hartshorne, H. and May, Mark, 1929).
6. Standards and ideals "must be tools rather than objects of esthetic appreciation."
7. Specific standards, attitudes, and modes of conduct, achieved must be integrated and purposefully expressed in wholesome thought and action to be effective in conduct.
8. If ideals are to become permanent, their trait actions must be repeated until they have become habitual. (Charters, W. W., 1928).
9. The one hour-a-week contact of the Sunday School modifies only slightly standards of every day conduct. (Bro, Marqueritte H., 1935).
10. Interest or disinterest is not a wholly reliable sign of value. (Carmichael, P. A., 1938).
11. Values are determined by experience in the last analysis.
12. Prevailing ways of inculcating ideals do but little good and may do some harm. (Chane, Ernest J., 1938).
13. Controlling behavior by means of abstract ideals can only be achieved by aiding satisfactory adjustments to existing groups and the development of a related normal growth of personality resulting in constructive emotional expressions. (Karpman, B., 1941).
14. A functioning ideal of society must be derived from the nature of the social life and growth as experienced by the individual. (Royce, J., 1920).

Consequently it is quite apparent that the religious development of the individual would be furthered by: natural situations being used for specific teaching, incidental and indirect methods selected in preference to the commonly used direct method of teaching, preaching and other administrative procedures.

2. CHARACTER IN PSYCHOLOGY OF RELIGION.

Again, the significance of the individual's life situation is emphasized. The small community gives the ideal situation for character influence where the issues do not seem to be so complex. The findings are:

1. "No one is honest or dishonest by nature." (Hartshorne, H., and May, Mark, 1928).
2. There is "need for careful educational analysis of all situations being used for teaching purposes."
3. The organization of consistent character is hindered by the "contradictory demands made upon the child by the varied situations in which he is responsible to adults." (Hartshorne, H., and May, Mark, 1930).
4. A character education program must make preliminary diagnosis of the present tendencies and weaknesses of each individual, discover his sources, and cooperate with him where he is now in the development of increasingly better character traits.
5. "The ideals issuing from experience must become prepotent factors in the stimulation of further conduct", and must aid "in the achievement of satisfactory modes of adjustment to new aspects."
6. Groups small enough to provide for cooperative discussion and effort to give moral support, aid in the "adventurous discovery and effective use of ideals in the conduct of affairs."
7. The home is the most influential factor in the formation of character of children. (Dimack, Hedley S., 1938).
8. Character education must strive to develop the child's social sensitivity and give him a sense of worth through success in programs of action. (Dimack, Hedley S., 1938).
9. "There must be assumed a flexible functional attitude that recognizes degrees of right and wrong, and types of personalities that react differently to problems of right and wrong." (Jacobs, Jessie A., 1939).

3. CHILDHOOD IN RELATION TO PSYCHOLOGY OF RELIGION

The interests and capacities of children condition religious processes, for they are little different than when these same children are in day school. A few of the major findings are:

1. Religion must recognize extreme intellectual, emotional, and social differences between children.
    (1) The superior student is above average not only intellectually but also in achievement, in play interests, social traits, emotional and moral development, and health and physical measurements. (Darley, John G., and Paterson, Donald G., 1934).

  - (2) The retarded student is below average not only intellectually but also physically, socially, and morally. (Newland, T. S., 1939).

  Educators must find and concentrate on the development of a specific skill in a field for which the retarded student shows some interest and ability. (Mueller, J. A., 1939).

2. The child needs a reliable and stable environment which will enable him to anticipate what is coming next in a world where sudden and unexpected changes are continually taking place. (Peller, L. E., 1939).
3. Affective behavior of the child is structured according to the dynamic relationships which exist between the situation and the needs of the individual. Earlier experience is very determinative of the direction emotion may take. (Emme, E. E., 1940).
4. The child should be taught emotional expression rather than inhibition, to live his emotions rather than talk about them. (Morgan, J. B., 1934).
5. The credulity of little children makes the trust of parenthood and teachers sacred. (Emme, E. E., 1940).
6. Leaders of children must cultivate a spirit of helpfulness, kindness, cheerfulness, obedience, and loyalty in children by example and by making possible for them opportunities of growth in Christian (sharing with others) living.
7. Personal security and a feeling of belonging give a child motivation toward more wholesome and objective expression of his personality.
8. Childhood leadership experience under Church Auspices rather than emphasis upon childhood beliefs.
   - (1) Adult religious experience was vitally developed by childhood leadership experience in connection with the Church. (Barker, L. V., 1934).
   - (2) Success and ability to get along with others is best developed by leadership development among and with others. (Darley, John G., and Paterson, Donald G., 1934).
   - (3) Lack of social understanding is one of the primary causes for the unsuccessfulness of workers. (Crane, G. W., 1938).

4. ADOLESCENCE IN RELATION TO A PSYCHOLOGY OF RELIGION.

The interests and capacities of adolescence condition appropriate religious processes for them. A few of the findings are:

1. Shifts of ideas are more likely to come about at high school age than at college age. (Van Toyle, M. C., 1938).
2. Youth from homes of different religious backgrounds tend to accept the religion of their parents. (Bell, H. M., 1938).

3. Church membership of youth is closely related to the population density of various areas. (Bell, H. M., 1938).
4. Some very important research substantiates present-day religious education hopes for the gradual development of the children and youth into mature religious persons. (Dimack, Hedley S., 1937).
5. Adolescents express a personal interest in Religion.
6. A program of controlled and properly supervised self-government in the adolescent's social functions aids his development of the interest, self and social responsibility, and directed effort. (Mowrer, C. H., 1939) (Landis, P. H., 1940).
7. Social conditions influence moral and religious thinking to a much greater extent than biological conditions, thus adolescents are amenable to educational control and direction. (Dimack, Hedley S., 1936).

5. ADULTS IN RELATION TO A PSYCHOLOGY OF RELIGION.

The life issues of adults vary considerably. Their needs and interests can not be assumed as generally understood everywhere. A few of the basic findings are:

1. While most abilities reach their peak between the ages of 15 and 30, the best contributions to the functioning of society are made by men from the age of 30 to 80. (Guilford, Jr., P., 1939).
2. Vocational responsibility specifically relates to the quality of life; socio-economic status is very determinative of human adjustment and success. (Emme, E. E., 1932).
3. "When two religions of radically different types are brought together in the marriage relationship usually the elimination of one, or an attempt to merge both, has not resulted very satisfactorily." (Emme, E. E., 1940).
4. The Church aids adults to get away from selfish, introverted tendencies and leads them to launch out in the larger issues of life where others live. (Link, Henry, 1936).
5. Adults need to decide on some course of life worthy of their greatest loyalty and effort.
6. Adult emotional security depends upon one's being recognized as a person of value to others and a conviction that one can do something really well. (Pratt, G. K., 1933).
7. Activities should never be abruptly stopped, but changed in accordance with altered capacities. (Emme, E. E., 1940).

CONCLUSION

Valid data concerning ideals, character, children, adolescents, and adult were presented. It is quite clear that ideals could be fostered in a more effective way by use of the incidental method especially when natural teaching situations are utilized. Children, adolescents, and adults have interests and capacities peculiar to their age and condition; that these must be utilized if a psychology of religion is to be well founded. A psychology of religion need not fear valid psychological findings if they are related to *a vital understanding* of human nature.

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REPORTS

SPEECH SOUND STATUS OF INFANTS DURING THE SIXTEENTH, SEVENTEENTH AND EIGHTEENTH MONTHS

FRANCES J. ANDERSON

The speech sounds of twenty-nine infants from the sixteenth to the eighteenth months were transcribed in the International Phonetic Alphabet. Comparisons were made of vowel and of consonant frequencies as between each of the three months. Further comparisons were made with other age groups in order to show the developmental status of the use of speech elements of the age group.

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SPEECH SOUND STATUS OF NEWBORN NEGRO AND WHITE INFANTS

HAN PIAO CHEN

The speech sounds of 50 white and of 30 negro newborns were transcribed in the International Phonetic Alphabet. Comparisons were made between the two groups. Further comparisons were made of these two groups with older infants and with adults.

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COLOR EXPERIMENT WITH CATTLE

EARLE E. EMME

Findings.

1. General attention to red, white, black and green banners ranked first.
2. The white banner received more attention than either the red, black, or green banners.

3. The red, green, and black banners received equal attention.
4. The red banner, contrary to traditional belief, did not excite the cattle to any greater degree than did any one of the other banners and less than the white one. (For further details see J. of Psychol. 12:183-184. 1941.)

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THE SCALING OF WORD ATTRIBUTES

C. HESS HAAGEN

The need for learning materials, quantified as to their degrees of relatedness in meaning, has become increasingly evident as learning experimentation and theory imply more and more the important role which similarity may play in transfer phenomena. The present study was undertaken to provide materials which might be used in a more direct attack upon this and related problems.

Eighty series of five two-syllable adjectives, related in meaning and paired with a common base word, were presented to three groups of judges. They were asked to allocate these word pairs to a seven point scale by a modified equal-appearning intervals technique. One group of judges scaled according to the defined relation of meaning, the second rated the strength of associative connection, while the third evaluated the vividness of connotation of the word-pairs. A fourth group of judges rated their familiarity with the words on a five point scale. From these judgments, the scale values of the four hundred word-pairs were obtained for each of the word attributes.

A comparison of the scalings of these three word attributes is made and their implications for learning experimentation discussed. From the familiarity ratings, observations on the recognition vocabulary of college undergraduates and the influence of uncertainty upon scale ratings are made.

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THE SPEECH SOUND STATUS OF A SMALL GROUP OF LOW-GRADE FEEBLE-MINDED CHILDREN

Orvis C. Irwin

The speech sounds of a group of ten feeble-minded children with an average age of three years were transcribed in the International Phonetic Alphabet at a year's interval. Comparisons were made of the two transcriptions.

Further comparisons were made of the transcriptions of these feeble-minded children's records with six month old infants and with adult speech sound transcriptions.

Iowa Child Welfare Research Station,

State University of Iowa,
Iowa City, Iowa

THE EFFECT OF VARYING ILLUMINATION ON DISTANCE PERCEPTION OF OBJECTS SUBTENDING ANGLES OF FROM 10-30 MINUTES

A. R. Lauer and Merwyn Winterstein

The problem relates to the effect of distance judgment under conditions of semi-scotopic vision. The levels of illumination ranged between .01 and 1.30 foot candles. Two series of experiments are reported. The first series used 16 subjects with illumination levels ranging between .04 and 1.30 foot candles. The second series used seven subjects between the ranges of .01 and .04 foot candles.

Time and errors were used as the criteria of performance. Both showed considerable variation throughout the series but greatest effects are noted below .03 foot candles. The time for setting varied more than the error score. Differential settings for colored test objects are given.

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PERCEPTION OF BODY TILT

EARL SCHUBERT

In the experimental runs the subject sat in a chair on a platform about five feet square. The platform could be tilted either by the experimenter or by manipulations on the part of the subject. The amount of tilt was controlled by means of a hydraulic system, which was relatively silent. The subject was carefully blindfolded during all trials. For each trial the experimenter set the platform at a pre-determined angle of tilt and then signalled the subject to bring himself back to the level position. Measurements were made for both longitudinal (forward-backward) and lateral (sidewise) tilt. The principal finding was that "errors of adjustment" were less for lateral than for longitudinal directions of tilt.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA

THE USE OF THE WECHSLER-BELLVUE INTELLIGENCE TEST IN THE STUDY OF MENTAL DETERIORATION

BERNARD WEBB

It has been suggested that the Wechsler-Bellvue intelligence test may be useful in the study of mental deterioration. The general purpose of this paper, then, is to investigate the usefulness of this test in measuring mental deteriorations and discerning its nature. This, in turn, involves two problems: (1) Do the various types of mental deterioration show characteristic test score patterns? (2) Is it possible, by the use of the differential test score method (balancing of certain sub test scores affected by mental deterioration against the sub test scores of those which are relatively unaffected), to devise differential indices for the various types of mental deterioration?

In answering the first question, two methods were used. The first method was that of determining the mean of the sub test scores in each diagnostic group and arranging in rank order. The other method used was that of considering the significant deviations of the individual sub test scores from the mean of each individual test.

As to the second problem, Wechsler has proposed a ratio that he feels will hold in normal and organic mental deterioration, and Dr. A. I. Rabin has proposed a differential ratio for schizophrenic deterioration. The validity of both ratios was checked.

The test results used were those of approximately 80 schizophrenics, 15 epileptics, 25 paretics, and 15 alcoholics.

The results from this particular group so far tend to show no significant differences in the test score patterns of the various psychoses, and the proposed ratios to be of little use. The Wechsler-Bellvue test seems to be only what it was devised to be, i.e., a test of intelligence and of very little value in the study of mental deterioration.

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THE USE OF THE STANDARD PARTIAL REGRESSION COEFFICIENT IN CONSTRUCTING GENERAL BOTANY ACHIEVEMENT TESTS

W. H. BRAGONIER

Since 1926, various aspects of the general botany teaching program at Iowa State College have been studied. Victor (1933) and Dietz (1935) described studies dealing with teaching procedures and techniques and evaluation practices. Kreutzer (1935) and Dietz and Gould (1939) reported on certain phases of the testing program, particularly the practice of grouping students enrolled in Botany 101 according to scores made on pretests. Bragonier (1941) described the methods used in constructing and evaluating the pretests. The value of grouping the students for instructional purposes is generally acknowledged within the botany department, however, the means by which the students are grouped is not as well accepted and, consequently, was chosen as the subject for this study.

A pretest consisting of fourteen problems was constructed for use in grouping the students enrolled for the fall quarter, 1939, in Botany 101. After the test had been administered, the responses to the fourteen problems were studied for purposes of improving the pretest. At the beginning of the winter quarter, 1941, a test of twelve revised problems was used to group the Botany 101 students. The responses of 94 students were used in studying the various problems in the test, and the data which follow are based on those responses.

The pretest is evaluated on the basis of its validity and reliability. Wert (1938) described validity as the extent to which a test measures that which it is supposed to measure, and reliability as the degree to which the test is accurate in measuring whatever it happens to measure. Accordingly, the pretest to be valid and reliable should provide an accurate estimate of probable achievement in botany.

The use of the coefficient of validity makes it necessary to have some criterion with which the pretest may be statistically compared. The criterion used as a measure of achievement in botany is the botany grade given to each student in the winter quarter, 1940. Two additional criteria used as measures of general achievement are the grade-point average of each student in the winter quarter and the score of each on the American Council on Education Psychological Examination, Form 1938, (hereafter referred to as the aptitude test). Each student's score on the aptitude test is available shortly after his registration in Iowa State College.

The coefficients of validity for the pretest are the correlation coefficients between the pretest and the criteria. These coefficients are presented in Table 1.

Table 1. Coefficients of validity for the pretest used to group the students enrolled in Botany 101, winter quarter, 1940.

Criteria used as measures of achievement	Coefficients of validity for the pretest. winter quarter, 1940
Botany grades for the winter quarter, 1940	.60
Grade-point averages in all subjects for the winter quarter, 1940	.66
Aptitude test scores	.60
(1% level of significance = .267)	(Fisher, 1937)

The data in Table 1 show that the coefficients of validity are highly significant values. Since these coefficients fall within the limits suggested by Dunlap (1939), it may be concluded that the pretest is probably a valid estimate of achievement as measured by the botany grades, the grade-point averages, and the aptitude test scores.

Wert (1938) and Dunlap (1939) suggested the split-half reliability coefficient and the index of reliability as measures for estimating the reliability of a test, and they described the methods for computing these values. The coefficient of correlation between the two halves of the pretest, .66, is substituted in the Spearman-Brown formula to obtain a split-half reliability coefficient of .80. The split-half reliability coefficient furnishes an estimate of the reliability of the whole test from the reliability of each half.

The index of reliability is obtained by extracting the square root of the reliability coefficient, .80, and is equal to .89. It furnishes an estimate of the correlation expected between scores on the pretest and true achievement scores.

The values of these estimates of reliability fall within the limits suggested by Dunlap (1939). It may be concluded, therefore, that the pretest score probably provides a reliable estimate of achievement in botany.

Since the coefficients of validity, reliability, and the index of reliability are all values that are highly significant according to Fisher (1937) (1% level of significance = .267), and since they fall within the limits set by Dunlap (1939), it may be concluded that the pretest is probably a valid and reliable estimate of achievement in botany.

Considerable time was involved in administering and scoring twelve pretest problems, and a method involving less time and less expense was desirable. Cox (1940) suggested using scores from a shortened pretest in conjunction with the scores on the aptitude test since such scores were readily available at no additional expense from the office of the Dean of the Junior College. In acting upon this suggestion, a method for selecting the more desirable problems from the pretest becomes necessary.

Hawkes, Lindquist and Mann (1936) suggested that the best constructed test, theoretically, is one in which the individual problems correlate highly with the criteria and show low intercorrelations. On this basis, a shortened pretest would be composed of problems that correlate highly with the botany grade, the grade-point average in all subjects, and the aptitude test scores, and which show low intercorrelations.

To rank the pretest problems, a tabulation of the number of intercorrelations and correlations with the criteria was made. These data are presented in Table 2.

Table 2. Rank of each problem of the pretest used for grouping the students enrolled in Botany 101, winter quarter, 1940, according to the number of significant and highly significant intercorrelations and correlations with the criteria.[1]

Problem Number	Number of intercorrelations		Number of correlations with the criteria[1]		Rank
	Highly Significant	Significant	Highly Significant	Significant	
1	6	2	3	0	8
2	3	2	3	0	3
3	3	0	3	0	2
4	4	3	3	0	5
5	7	2	3	0	10
6	4	1	0	1	12
8	0	1	0	1	11
9	1	2	2	1	1
10	4	1	3	0	4
11	8	0	3	0	9
12	7	0	3	0	6
13	7	0	3	0	7

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[1] Botany grades, aptitude test scores, and grade-point averages in all subjects for the winter quarter, 1940, are the criteria.

The data in Table 2 show that problem 9 ranks first on the basis of showing three significant intercorrelations and correlating significantly with the criteria. Problem 6 ranks twelfth because it shows only one significant correlation with the criteria and five significant intercorrelations as compared with problem 8 (rank eleven) which shows one intercorrelation and one correlation with the criteria, both of which are significant.

Since only three of the twelve problems do not show highly significant correlations with all three criteria, the other nine problems must be ranked on the basis of the number of intercorrelations. The data show, however, that problems 4, 12, and 13 have the same number of intercorrelations; therefore, these problems have to be ranked on the basis of very small differences between the correlation coefficients.

The difficulties encountered in attempting to select problems on the basis of low intercorrelation and high correlation with the criteria make it necessary to find some other method for selecting the most desirable pretest problems to be used in conjunction with the aptitude test scores for grouping the students enrolled in Botany 101.

Cox (1940) suggested use of the betas (standard partial regression coefficients) for purposes of ranking the problems according to predictive value. The beta of a problem gives an indication of the extent to which that problem contributes to the value of the test as an instrument for predicting achievement.

The betas are independent of the units of measure and are directly comparable values. The beta of each variable is dependent on the contribution of every other variable present in the multiple regression. When a variable with a low beta is removed from the regression, new betas must be computed for all variables. Some of the new betas may be higher or lower than they were before, since part of the influence contributed by the variable that was removed may be added to or subtracted from the betas of other variables.

The method outlined by Wallace and Snedecor (1933) was used for computing the betas presented in Table 3.

Table 3. Rank of each pretest problem, winter quarter, 1940, according to the standard partial regression coefficient (beta),—botany grade dependent variable.

Problem number	Beta	Rank of problem	Problem number	Beta	Rank of problem
1	.1550	7	8	-.0166	12
2	.1357	8	9	.1766	6
3	.2410	2	10	.1929	4
4	.3127	1	11	.2212	3
5	.0516	10	12	.1338	9
6	.0269	11	13	.1811	5
*R (problems 1-6) = .5617			*R (problems 8-13) = .5781		

(Significance levels of R: 5% = .358, 1% = .409) (Fisher, 1937)

*R = the multiple correlation coefficient

The data in Table 3 show the rank of each problem according to the size of the beta, although some error may be involved as the betas were computed for each half of the test in separate regressions. Since the multiple correlation coefficients (R) for each half are nearly the same in value, there is little cause for concern in this regard.

The data in Table 3 indicate that the problems which contribute least toward predicting the botany grades are problems 6 and 8. If these two problems were deleted from the test and new betas were computed, one would expect little change in the predictive value of the test as a whole.

Since the ultimate goal is to obtain a short pretest to use in conjunction with the aptitude test, the computation of betas for the remaining ten problems plus the aptitude test would provide data that might indicate the extent to which there were common elements present in the two tests. The data from such a computation would show which problems were contributing least in the way of elements different from those present in the other problems and the aptitude test.

Table 4. Rank of each of ten pretest problems,** winter quarter, 1940, according to the standard partial regression coefficient (beta) computed in the presence of the aptitude test,—botany grade dependent variable.

Problem number	Beta	Rank of each problem
1	.0489	7
2	.0405	8
3	.1345	2
4	.1692	1
5	-.1261	5
9	.1335	3
10	.1279	4
11	.0305	9
12	.0259	10
13	.0827	6
Aptitude test	.4483	
	*R = .7207	

(Significance levels of R: 5% = .576, 1% = .615) (Fisher, 1937)
*R = the multiple correlation coefficient

Judging from the size of the multiple correlation coefficient (R) shown in Table 4, it may be concluded that the combination of the ten problems and the aptitude test furnishes a better basis for predicting botany grades than does either half of the pretest (Table 3). Furthermore, the betas of problems 1, 2, 11, 12, and 13 as given in Table 4 show there is little in the way of predictive value to be gained by use of these five problems when the aptitude test is being used. Consequenty, elimination of these problems should result in no appreciable change in the predictive value of the combination and would result in a reduction of the time necessary for administration and scoring of the pretest problems.

Table 5. Results of the study of five pretest problems, winter quarter, 1940, showing the coefficients of standard partial regression, and multiple correlation in the presence of the aptitude test scores with the botany grades as the dependent variable.

Problem number	Beta
3	.1397
4	.2055
5	-.0888
9	.1555
10	.1350
Aptitude test	.4838
	*R = .7089

(Significance level of R: 1% = .409) (Fisher, 1937)
*R = multiple correlation coefficient

**Problems 6 and 8 have been eliminated.

In Table 5 are presented the data obtained when problems 3, 4, 5, 9, and 10 and the aptitude test are present in a multiple regression. These data show that the multiple correlation coefficient (.7089) is smaller than that in Table 4 by only .0118. It would seem, then, that elimination of five problems (problems 1, 2, 11, 12, and 13) results in only a slight change in the predictive value of the combination, and the labor involved has been greatly reduced in that the pretest now consists of five problems instead of ten.

The five-problem pretest was administered to each student enrolled in Botany 101, fall quarter, 1941. The score from the pretest was combined with the aptitude test score, and the resulting master score was used in placing the students in high and low groups for purposes of instruction. After the completion of the fall quarter, 1941, the records of eighty-four students were studied to determine the manner in which the scores from the pretest should be combined with those from the aptitude test, and to determine the validity coefficients for the master scores, the aptitude test, and the five-problem pretest.

To determine the method for combining the aptitude test and the pretest scores so that a valid master score would result, a multiple regression equation was computed for predicting botany grade from the two variables. This equation revealed that the aptitude test score should be doubled and added to the pretest score to obtain the master score. New master scores were computed from the records of the fall-quarter students and the coefficient of validity for the new master score was obtained. This coefficient and the coefficients of validity for the aptitude test and five-problem pretest are presented in Table 6.

Table 6. Coefficients of validity for the various estimates of probable achievement in botany. Data based on the records of eighty-four students enrolled in Botany 101, fall quarter, 1940.

Criteria used as measures of achievement	Coefficients of validity for the master score (two times the aptitude test score plus the pretest score)	Coefficients of validity for the aptitude test	Coefficients of validity for the five-problem pretest
Botany grades	.53	.52	.39
Grade-point averages in all subjects	.54	.57	.39
Final test scores	.61	.62	.49

(Significance levels: 5% = .217, 1% = .283) Fisher (1937)

The data in Table 6 show that the practice of doubling the aptitude test score and adding the product to the pretest score will probably result in a valid master score for predicting achievement in Botany 101. The data in Table 6 also show that the coefficients of validity for the aptitude test are for all practical purposes as large as those for the master score. The question immediately arises as to the advisability of giving a pretest when there is little or no additional increase in predictive value over that available from the aptitude test alone.

Beginning with the fall quarter, 1941, the Botany 101 students have been grouped on the basis of the aptitude test scores. As far as can be determined without extended research, this method is satisfactory.

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TEACHING TO THINK IN A FIELD RATHER THAN ABOUT IT.

E. W. LINDSTROM

Perhaps the clearest definition of thinking *in* a field of study as the preferable educational approach is to recall Hazlitt's essay "On the Ignorance of the Learned" where he says, "If we wish to know the force of human genius we should read Shakespeare. If we wish to see the insignificance of human learning, we may study his commentators." Strong words, but they bring out the point. If not, think in terms of pure text-book learning.

Another helpful example may be found in Schopenhauer's essay "On Thinking for Oneself." Here it is pointed out that people who have spent their lives in reading and acquired their wisdom out of books resemble those who have gotten information about a foreign country from descriptions of travellers. These people can relate a great deal *about* many things; but at heart they have no connected, clear, knowledge of conditions *in* that country. While those who have spent their life in thinking, are like the people who have been *in* that country themselves; they alone know really what they are saying, know the subject in its entirety and are quite at home in it.

Thinking *in* a subject means a rigorous mental discipline giving mastery of a relatively few basic principles and knowing those principles thoroughly. That in turn means less of the usual parade of facts to be memorized, and, I hope, a minimizing of the huge number of educational courses which so burden our curricula and our catalogues. This trend has reached the level of a racket and necessitates the focussed attention of the teaching profession before we are hoisted by our own petards.

To generalize concerning educational methods and processes is not only dangerous but often exceedingly foolish because no one system is applicable to all the individualistic patterns of the human mind and the human spirit. We should, however, constantly refresh our thoughts and orient our ideas in the fundamental truths of the learning process. I have been flattered by the Program Committee into giving some of my experiences in teaching the elementary courses in Genetics over a period of a quarter century. In this course I have tried to make this field a living subject by stimulating thinking *in* rather than *about* this science. We have tried to emphasize "what is under the hood" rather than to memorize the superficial aspects of an automobile. This method is not easy; the poorer students require nearly a full term to grasp what the instructor is driving at, because they have become so thoroughly immersed in, and drugged by, the prevalent memory and regurgitation schemes.

The techniques are not new, they merely need re-emphasis and possibly further discussion. At any rate, the objective of this paper is merely to re-stimulate thinking along these lines because education, like all other disciplines of the day, is being re-evaluated in terms of integration into a changing world.

Our methods of instruction center around two principles:

(1) a thorough understanding and mastery of a half dozen concepts or principles

(2) an inductive scheme of weaving common, every-day facts into a systematic whole.

This we do by the usual techniques of lecture-demonstration-discussion in the class room, by regular sets of problems designed to stimulate creative thinking, by optional outside readings (no text book used in the course), by optional review or discussion sections, and finally by as many essay-type examinations as possible. Running through the course, but never formally expressed, is the scientific method of acquiring knowledge, largely inductive. The student soaks up the manner in which scientific observation and "the barn-yard facts of life" are woven into hypothesis, theory and finally into law. There emerges the half-dozen generalizations which we think essential for the university student. In our specific course, these are the gene-chromosome system with its applications to simple and quantitative inheritance, the story of inbreeding and heterosis, the heredity-environment problem, the integration of all these into the principle of organic evolution and finally the applications to plant breeding, animal breeding and problems of human biology. The students are conditioned to the idea of mastering these few fields.

Memory and professional jargon are at a bare minimum. Necessary formulae or mathematical approaches are first handled by 'brute strength and awkardness' and then later formalized, but only the best students are expected to master the abstract formulations and to express them in mathematical formulae.

How different from much of orthodox teachings! For example my daughter in high school algebra has just 'finished' the section on the binominal theorem. Both text and instructor go no further than to work out and memorize that long formula for expanding a binominal. Their examinations ask for the 3rd or the 7th term of a series. Nowhere is the student given an insight into the meaning or real application of that formula. How easy to approach it first by 'brute strength' taking for example, the determination of the probability of the numbers of boys and girls in families of two children, of three children, of four children, etc. I trust that this example is not characteristic of the teaching of mathematics.

How often do we teach cell-division in biology with its mere memory of terms (prophase, metaphase, etc.) leaving the student with no real understanding of the real function or dynamics of this vital process which is far more than to make two cells where one was before. The entire concept of life's stability or its lability rests upon cell reproduction, somatic or germinal.

How often do we spend hours and hours in elementary courses of biology on the detailed morphology of a grasshopper or the sex-life of a fern and slight the vital problems of human health, nutrition, physiology and heredity. Why? Usually because our teachers have learned these very details themselves in their specialized courses and have never had occasion to think deeply in the science of life. One can teach physiology, nutrition or heredity before all the details of morphology, cytology, taxonomy, etc. are mastered. Often the latter can be given as advanced courses just as well, if not better. Preferably, of course, they can be included in the so-called applied courses.

You might be interested in the very recent (1942) evaluation of "The Teaching of Biology in Secondary Schools of the United States" by the Committee on the Teaching of Biology of the Union of American Biological Societies. Teachers of biology were asked to submit "the 4 or 5 topics on which they would place the most emphasis in a high school course in general biology." The committee believes that the results of this questionnaire would reveal the "trends and present effectiveness of biological teaching in our schools." A total of 866 teachers in 15 states replied, listing twenty-two topics.

The top five items listed in order with their votes were as follows:

1. Health-disease-hygiene (397)
2. Heredity-genetics (282)
3. Physiology (263)

4. Conservation (127)
5. Structure (102)

The lowest, or least popular, topics were:

18. Eugenics (31)
19. Behavior (29)
20. Scientific method (21)
21. Biological principles (13)
22. Photosynthesis (13)

Intermediate topics were: Reproduction (90), Taxonomy (88), Ecology (88), Nature Study (87), Environment (67), Insects (53), Nutrition (52), Economic Biology (50), Life Processes (49), Sex Education (39), Evolution (39), Adaptation (37).

This list merits a fuller discussion than time permits. But it is significant that biology teachers in secondary schools are beginning to realize the functional aspects of their science. Nevertheless, there still exists the danger that in motivating students with these functional or applied phases the discipline becomes superficial and not rigorously mental. Such a suspicion easily arises when such topics as photosynthesis and biological principles land at the bottom of the list. Certainly good, basic science can be given in the applied phases of science, but the courses must so be planned.

The editors of the above report deplore the trends, feeling the data show "widespread tendencies to teach biology not as a science but (a) as a way to pleasing hobbies, or (b) as a series of practical technologies." Further they state as axiomatic in college and university levels, the rule, "The basic sciences first, applications afterward." I have a faint suspicion that the truth lies between these extreme viewpoints, certainly so at the secondary level and often so at the junior college level. When elementary 'basic sciences' are taught as an end in themselves without real integration or application to life they often have the record of killing interest in the great majority of students so that they never attain the 'applications afterward'. If these 'basic sciences' are taught as they can and should be, they may well include the two aspects, theoretical and applied. This opens the road for thinking *in* the field rather than *about* it.

It is no new experience to teachers of senior college courses that students enter with shockingly little understanding of the 'basic courses'. In my own experience, it is the rare student who can use his mathematics or his biology, to say nothing of his English and logic, in a new field when the use of those tools calls for a slightly different approach from his memorized (and forgotten) learning. Accordingly, I am less and less concerned with any prescribed order of learning, basic or applied, first or last. What is important is that the student shall have discovered how to use his mind and his learning. Mere book learning is not enough. The student, like the real citizen, must be first of all a man of intellectual action (thinking) as well as a storehouse of half-forgotten class-room ideas.

Too much reading or too much school-room learning robs the mind of its elasticity. This makes many men more stupid and foolish than they are by nature. This condition may often be discerned in men of learning, making them inferior in sound understanding, correct judgment and practical tact to many illiterate men who, by the aid of experience, conversation and a little reading and learning, have acquired a knowledge making them capable of action. They do their thinking in their activity. It is what a man has thought out directly for himself that alone has true value.

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THE TEACHING OF BOTANY—APPRAISAL AND FORECAST

W. F. LOEHWING

In undertaking a discussion of biology in education it is highly desirable to view the subject against the general background of American education as a whole. Among the nations of the world, the United States possesses the unique distinction of having mass education. We owe this policy to the shrewd foresight of the fathers of the American revolution, to their recognition of the fact that the success of representative government depends upon an enlightened electorate. As an object of primary importance, George Washington enjoined the new nation to "promote institutions for the general diffusion of knowledge." In his first inaugural address he stated that "as government gives force to public opinion, it is essential that public opinion should be enlightened." Though we as individuals commonly regard education as a means of improving our economic status, American statesmen have never lost sight of its greater importance in making democracy feasible. Because the civic value of education far transcends its benefits to the individual student, a system of free public was established and the education made compulsory.

Both the broad, civic function and the service of education to the individual currently engage the attention of public officials and educational administrators in an attempt to make both purposes more effective. The opinion is widespread that our public schools have failed to awaken an effective interest in public affairs and that they do not properly prepare our youth for self-support. Generally speaking, most of us will probably concede that it is worth while to improve the effectiveness of our public schools in these areas.

An over-all view of the present social order discloses that we live in an era of technology and invention. Technological advance has been so remarkably rapid that our social economy has been unable to keep up with it. The general mechanization of industry and agriculture have created serious problems of unemployment and economic maladjustment. Up to the present, our social wisdom has obviously lagged far behind America's scientific and inventive genius.

The solution of the problem is not a declaration of a moratorium upon science but rather the discovery of ways to prevent recurrent upheaval of our entire economic system in the wake of each new technological advance. We are confronted with the necessity of making social adjustments concurrently with rather than long after industrial advances. The existence of these conditions explains the desire of statesmen and educators to awaken a greater public interest in and to improve understanding of politico-economic problems thru the instrumentality of our public schools.

As a forecast, it looks like the American public is in for a rigorous course of instruction in the social studies as these relate to economics and political science. J. W. Studebaker, the present United States Commissioner of Education, has recently said that "It has been one of the chief concerns of the United States Office of Education in the past few years to promote civic education, not because other phases of education are not vital and important, but because civic enlightenment is now crucial. Without it we shall lose the freedom to educate and slip back into a dark age of partisan domination and severe restriction of the learning process itself." (Education Moves Democracy Forward, Columbia University, 8/17/39). This trend in American education will be given additional impetus by the social readjustments destined to emerge from the present world conflict.

The tendency toward increasing emphasis on social studies naturally has already had an influence upon biology as presented in our public schools. Current interest tends to center increasingly in those phases of biology which underlie legislation and social usage in relation to man, agriculture and medicine. Eminent civic leaders and school administrators have recommended that biology and science education be reorganized to present them in their bearing on social action. Perhaps this sounds as if biology is destined to be the tail on the sociological kite and that biology will occupy only a subordinate place in the educational picture. Rather the contrary. No one will dispute that the social sciences rest largely on a biological foundation and the better that foundation, the more effective will be the sociological program based thereon. This is but another way of stating that biology is the logical starting point in what promises to be the major educational emphasis resulting from the present world crisis. This new interest in biology will be added to man's ever-present interest in himself as a living organism.

One reason that the momentum of the existing trend toward biology has not been more widely recognized in educational circles is that mechanical and technological innovations are more spectacular and they thus tend to overshadow recent yet epochal advances in biology. Technology overshadows biology especially in time of war. As the backwash of war and post-war reconstruction engulf us, however, there will occur a shift in emphasis from technological to social values. In war, mechanical and industrial products are paramount; even human life becomes a minor consideration. In post-war readjustment, however, the human element again becomes dominant and draws biological considerations of all in its wake. Many of us still remember this trend in education as an aftermath of the last war.

Turning specifically to the biological values which apparently will rank high in our future social life, I would place human well-being first. Prime among the social values will be the *health* of the nation. Need for greater conservation of human health has already become painfully evident in the rejection for physical disability of about 30% of the draftees called up for armed service. The estimated cost of medical care is $28 per capita or about $100 per family annually in the United States, a cost which reaches an aggregate of three and one-half million dollars or about five percent of the total national income. After all, children are America's most valuable crop and in the future as a matter of national economy we need to do a better job of caring for them than we have done in the past.

The importance of biological education in this movement is readily evident. The care of the human body will receive more attention in schools than ever before. Greater and more widespread knowledge of diet, housing, and health will be disseminated in our schools to parent and youth alike. The biology teacher will in the future be called upon to assist much more extensively with the scientific phases of public health and recreation. Food as it relates to better health will entail changes in the dietary habits of the nation and such changes will serve to focus interest upon human nutrition and the science of agriculture. Recent advances have already given a notable impetus to genetics as it relates to heritability of human disease. Over 100 defects of skin and eyes alone are now known to be congenitally transmissable. Heritable tendencies to diabetes, tuberculosis, asthma and allergy are also known. There is already an increasing demand for biology teachers familiar with the latest scientific developments in these areas.

These are but a few of the new developments already on the biological horizon.

These trends will also affect the future training of teachers. Biology teachers will find a practical inducement to acquaint themselves with the social sciences as they embody applications of biological principles. Professor John Dewey has stated that "the responsibility for a system of education akin to the method of science lies with those who already enjoy the benefits of special scientific training." It may, consequently, be the better part of wisdom for science teachers to become familiar with the major problems in the social area in order to inject more science into that field than to absorb sociological concepts into pure biology. Considerable confusion already exists, for example, in the field of eugenics because the biology of that subject is not clearly enough differentiated from its purely sociological aspects.

As one turns from the broader civic aspects of education to those dealing more specifically with the individual student, he also finds significant changes under way. These involve two major innovations in method and content. In connection with educational methods, it may be pointed out that certain as yet inconspicuous but nevertheless widespread tendencies have been gaining ground. There exists a definite movement in the direction of a balanced earn-learn program. This idea of providing job experience as an integral part of the student's schooling is by no means new and it has long been successfully practiced at the well-known Berea and Antioch Colleges. This policy, of course, has as its prime objective the immediate employability of the high school and college graduates and overcoming difficulties in obtaining their first full time job. The significant recent development has been the rapid expansion of this method of education, fostered largely thru outside subsidy as part of the national youth program.

The earn-learn program envisions enlarged opportunity for complete or partial self-support while the student is in school. Self-support is intended to provide not only the means to education itself for those who would otherwise be barred, but to introduce the elements of morale and job experience as well. As one scans census figures, it is evident that much needs to be done to make education accessible for some 3½ million youth who are not able to afford a high school or college education. Only 11% of our college age population are actually enrolled. Of the 21 million high school and college age group, nearly two thirds are excluded from schooling by pitifully small financial margins. Most of the 18 million out-of-school youth were unemployed and, ironically, often prevented from obtaining jobs because of child labor laws. The very laws which had been ideallistically enacted to prevent industrial exploitation of children, in the depression boomeranged viciously against the very group they were designed to protect. America was rapidly recruiting a vast army of disillusioned adolescents who were fast becoming militant in their desperate discontent.

The crisis was becoming nationally acute and the federal government stepped in at this juncture to head off the possibility of American fascism and communism. The National Youth Administration was started in 1935 as an emergency relief measure for the purpose of eliminating school age children from the labor market by financially subsidizing their return to school. It is interesting to note that with an opportunity to earn from five to twelve dollars per month, 650,000 children were restored to school. The Civilian Conservation Corps with similar objectives was also inaugurated by the federal government. As a job training project the CCC has proven highly successful and has enjoyed about a 40% annual turnover due to acceptance of permanent employment. On the other hand, jobs have been found for only one percent of school age youth on federal unemployment rolls. The CCC obviously possesses spot-value job training which the public schools lack.

As a relief measure, the federal government thus came into American education on a large scale for the first time in the nation's history. As unemployment diminished both the NYA and CCC have been continued largely as a nation-wide experiment with the earn-learn program. Both of these agencies have recently passed to the jurisdiction of the United States Office of Education and thereby become an integral part of comprehensive national youth program, which can be quickly put into operation if post-war exigencies require. It is very possible that problems similar to those of the depression may again arise with collapse of the present war boom.

One may ask how this shift in educational method will affect biology. The answer may prove to be that biology will be called upon to help create opportunities for gainful student employment in its applied phases, especially for those students who contemplate a vocation in this area of science. Formulation of details for such a program may not be difficult in vocational high schools and agricultural colleges, but real administrative ingenuity may be required to create such projects in our liberal institutions.

The inducement to find means of self-support at job training tasks for our students will probably come in the form of outside subsidy. The celerity with which we discovered all sorts of part time jobs as soon as NYA funds became available to our schools implies that no serious problem exists when there is a will to face it. Our NYA students have not only done much good work for us but the very existence of their projects has enabled many of us as teachers to obtain new facilities for practical work. Many of us have, for example, for the first time obtained a patch of ground for a garden and a greenhouse for utilitarian activity. The current shortage in important medicinal plants has already provided the impetus to hundreds of highly practical, self-liquidating drug-garden projects throughout the country.

The garden and other practical plant projects under governmental sponsorship has reciprocally created a demand for courses in applied botany. To a large degree classwork has moved from the laboratory to the greenhouse and to the out-of-doors. Such botanical information is much more exciting to the student because he acquires it himself instead of thru the textbook or lecture. Despite the informality of method, substantial quantities of sound scientific information appear to be gleaned under such informal auspices.

Obviously, if the earn-learn program is expanded and the methods of classwork become less formal, there is bound to be a commensurate effect on subject matter itself. Such tendencies are already evident on the plant side of biology, as can be readily gleaned from recent textbooks. We are, in fact, beginning to humanize the textbook and syllabus. For example, instead of tossing the leaf, stem, root, flower, fruit and seed at our classes like the pieces of a jigsaw puzzle and trusting to luck that the student will succeed in constructing a plant out of these parts, modern botanists present the plant as an entity by adoption of the developmental approach. The living plant, which has long threatened to come into the class room, has at last actually arrived—and with it an amazing increase in enrollment.

Students obviously prefer to work with the living plant, to start with a seed and to make it grow. These living cultures soon become personal pets and the student unconsciously responds to the subtle lure of life unfolding in his care, even if only in an ordinary flower pot or aquarium. Incidentally he always has the entire organism before him instead of as a miscellany of its separate parts. Experimentation with the living plant becomes something like manipulation of a mechanical gadget and provides abundant opportunities for student activity. The developmental approach with living plants readily sets the stage for the introduction of the functional side of applied botany better than the traditional structural departure without in any way excluding cultural phases of the subject. The developmental approach also makes it easier to keep courses student-centered instead of subject-centered.

I might add that recent developments in plant science offer the biology teacher a number of novel, yet definitely scientific experiments. The lay press has, for example, built up widespread interest in soilless culture of plants, a procedure readily adaptable to the classroom. Students are amazed by what they themselves can accomplish with a lot of water, and a few pinches of ordinary salts. Soilless cultures lend themselves not only to actual demonstration of symptoms of common nutrient deficiency diseases of plants but also to spectacular demonstration of recovery when the missing chemical elements are restored. Such experiments can be combined with studies on the effects of plant hormones and vitamins. Production of fruits by use of hormone smears instead of pollen is readily feasible and the seedlessness of such fruits creates enough interest in reproduction to enable the teacher to get across the scientific aspects of the process.

A graft of a tomato scion on a potato root-stock is easily made to provide training in methods of grafting. The production of potatoes and tomatoes on a single plant, always arouses interest and vividly demonstrates that different varieties can be grafted, as is commonly done in commercial horticulture. Herbaceous grafts are simple yet demonstrate basic practical methods. Such plants grow rapidly and results are evident much sooner than in woody species. Quick results are a great convenience to teachers charged with responsibility for the care of experimental materials.

Most students have heard of the use of canaries in warning miners of the presence of monoxide gas. Few students, however, have seen the epinastic response of tomato plants as a test for gas leaks, a demonstration easily obtainable in an ordinary laboratory period. In fact, one can go farther and by the same test demonstrate the natural emanation of ethylene gas from ripe apples. Such experiments set the stage for a discussion of the commercial process of coloring and ripening of fruits such as bananas and citrus by ethylene gas. These are but a few specific illustrations of contemporary biology capable of providing effective, dynamic classroom activity.

If the earn-learn program, with its less formalized classwork and emphasis on functional values is to dominate post-war education, the teaching of biology can be readily adjusted to it and itself be vitalized. Its diversified character will be new and as such refreshing to those of us who have so long employed the older morphological approach. Diversity of activity and the evident logic of development as obtained with living organisms will place a premium upon good pedagogy. The fine, subjective art of teaching will in the future have to be more subtly merged with presentation of the strictly objective facts of science. Consciousness of the need for skill in teaching and the dissemination of the newer facts of science seems to be reflected in the recent organization of progressive associations for science teachers and the establishment of current periodicals devoted entirely to the particulars of teaching in this field.

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COMPARATIVE STUDIES ON GONAD DEVELOPMENT IN THE RAT, THE PIG AND IN CATTLE(1)

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INTRODUCTION

The relatively clear and simple developmental pattern of the frog gonad (Witschi 1914, 1924, 1929) makes it a good basic type with which to compare the sex glands of higher vertebrates.

The frog gonad, before sex differentiation, consists of a germinal epithelium (cortex) containing germ cells and follicle cells, of a mesenchyme-filled primary gonad cavity (this mesenchyme later forming the primary albuginea), and of a series of rete cords (of mesonephric blastema origin) entering through the hilum and projecting into the primary gonad cavity. The rete cords constitute the primitive medulla. Testis differentiation occurs when all of the germ cells, each one with its follicle cell, move from the germinal epithelium into the medulla. The germinal epithelium becomes thin and devoid of germ cells. It remains separated from the medulla by the primary albuginea. The germ cells divide and together with the follicle cells form the contents of the seminal tubules: spermatogonia and Sertoli cells. The rete cells give rise to interstitial cells and the walls of the seminal tubules. The rete-tubule meshwork connects with the seminal tubules by tubuli recti, and with the mesonephric tubules by vasa efferentia. Tubuli and vasa are parts of the rete apparatus. In gonads differentiating into ovaries, germ cells and follicle cells remain in the germinal epithelium, which thickens to form the ovarial cortex. A cavity appearing in the distal part of the rete becomes the secondary gonad cavity. During the maturation process follicle cells form an envelope of granulosa cells around each ovocyte. The part of the rete applied to the follicles nearest to the gonad cavity forms the theca externa. Mesenchyme around the follicles give rise to the theca interna.

The origin and development of the elements of the sex glands of higher vertebrates, especially mammals, are not as clear as in amphibia. The different elements to be considered and studied in regard to their origin are: germ cells, germinal epithelium, cortex, medulla, seminal tubles, Sertoli and granulosa cells, thecae interna and externa, testis interstitials, rete apparatus, vasa efferentia, epididymis, vas deferens and oviduct.

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There are still two principal schools of thought concerning the origin of the germ cells. Germ cells may arise from somatic cells of the germinal epithelium, or from cells segregated early in development and bearing certain diagnostic characteristics. Adherents of the first view (Simkins 1923, Hargitt 1925, 1926, Goldsmith 1932) have not satisfactorily proven that somatic cells of the germinal epithelium can and do transform into germ cells; while many of those holding the second view (Rauh 1929, Rubaschkin 1910, 1912) have demonstrated that germ cells migrate from extra-gonadal sources and become definitive germ cells. Some workers (Bookhout 1937, Kates 1937) hold a compromise view that germ cells move into the gonad from extragonadal sites but degenerate and do not give rise to definitive germ cells. Regarding the vast controversial literature, we refer to the discussions of Heys (1931), Risley (1933) and Willier (1939).

The germinal epithelium is a layer of splanchnic mesoderm lying between the coelomic angle and the place of attachment of the intermediate mesoderm to the splanchnic plate; germ cells come to lie in and beneath it. Risley (1933) in the musk turtle and Witschi (1935) and Stanley and Witschi (1940) in birds, have described how the germ cells which first lie laterally distributed in the endoderm (turtle) or in the splanchnic mesodermal plates (birds) are brought into the midline by movements of the splanchnic mesoderm during the formation of gut and dorsal mesentery. Later they move into cortex, tunica albuginea and medulla of the primordial gonads.

All investigators agree that the ovarian cortex differentiates from the germinal epithelium. While some workers hold that seminal tubules of testes and medullary cords of ovaries of higher vertebrates originate from germ and somatic cells proliferated inward from the germinal epithelium, others (Blocker 1933, Witschi 1935, in birds; and Felix 1912 in man) have described seminal tubules and medullary cords as arising in situ from germinal and somatic cells lying in the medulla. The findings of Witschi and Blocker bring the mode of formation of seminal tubules and medullary cords of birds into line with observations on amphibia, with this difference: in the frog all germ cells at first lie in the germinal epithelium, and then, in the male, migrate into the medulla; whereas in other amphibia (*Ambystoma tigrinum*, Gilbert 1940) and in the birds (Blocker, Witschi, op. cit.) germ cells are already present in both cortex and medulla in indifferent stages.

As stated above, Sertoli cells of the frog testis are follicle cells of epithelial origin which accompany the germ cells when they move into the medulla. Opinions concerning the origin of mammalian Sertoli cells are many, but clear demonstrations of origin and source of these elements are lacking. Likewise, opinions differ as to the origin of granulosa cells in the mammalian ovary. It was shown by Witschi (1914) that in the embryonic frog ovary, each ovogonium is accompanied by a follicle cell of epithelial origin, and the granulosa layer of the follicles arises by the division of these cells. Kingsbury (1939) has recently reported that in the embryonic cat ovary, the granulosa layer of the primary follicle is of cortical origin, is one cell thick, and is bounded peripherally by a membrane, within which granulosa cells multiply. Pincus and Enzmann (1937) state that in the rabbit, the initial follicular layer arises from "spindle-shaped elements" and that these follicle cells increase in number to form the granulosa. Okamoto (1928) asserts that the initial granulosa layer of the dog ovary is derived from cortical somatic cells, but increases in thickness by the addition of mesenchyme cells.

It has been demonstrated in the frog ovary that the theca interna of the ovarian follicle is derived from mesenchyme, and the theca externa from the rete ovarii. In mammals, it has been shown that the theca externa arises from gonadal mesenchyme, while the origin of the theca interna is not clear. The internal theca cells (ovarian interstitials) of the cat have been said to arise from transformed mesenchymal cells (Kingsbury 1939, p. 310), but this has not, we think, been sufficiently substantiated. The question of origin and function of ovarian interstitials has been discussed by Stieve (1933), Corner (1938) and Kingsbury (1939).

According to recent reviews (Moore 1926, Rasmussen 1928, Maximow and Bloom 1938) most of the evidence indicates that testicular interstitials are transformed gonadal mesenchyme cells. However, Witschi (1939, p. 149) suggests that testicular interstitials "most probably derive from the rete cords which themselves originate from the mesonephric blastema."

The gonadal rete of the frog has been shown by Witschi (1914) to arise from accumulations of cells of mesonephric blastema origin between mesonephric tubules and seminal tubules; they form the rete network, tubuli recti and vasa efferentia in the testis, and the theca externa of ovarian follicles. There is no agreement as to the source of the rete in mammals. Opinions concerning this point fall into two groups. The rete is said to arise from the mesonephros (outgrowths from mesonephric tubules or renal corpuscles, or aggregations of mesonephric blastema cells), or from ingrowths from the coelomic epithelium. For recent reviews of literature on the origin and development of the gonadal rete see Wilson (1926), Bovy (1928) and Risley (1933).

The epididymis, it is generally agreed, is formed from mesonephric tubules that persist after extensive mesonephric degeneration. It serves as a storage place for the sperm and connects with the vas deferens (wolffian duct). In females, some mesonephric tubules persist in rudimentary form as the epoöphoron. The wolffian ducts disappear more or less completely.

The oviducts are structures which, in males and females alike, arise from the coelomic epithelium, lateral to the wolffian ducts. In females they persist while in males they degenerate.

The present study consists of a reinvestigation of the origin of the various elements of the sex glands in rat, pig and cattle, and of a comparison of the gonad development in these three forms with that occurring in amphibians.

I wish to express my gratitude to Professor Emil Witschi for suggesting this problem and for his helpful advice and criticism during the progress of the investigation.

MATERIALS AND METHODS

The rat material was obtained from a colony of Wistar rats. Pig and cattle embryos were collected on the killing floors of the Cedar Rapids, Iowa, branch of the Wilson Packing Co. The author wishes to thank the Wilson Co. for its cooperation and courtesy in making the specimens available.

Measurements of crown-rump lengths of pig and cattle embryos were made on fresh material immediately after removal from the uteri. Gonads of smaller specimens were sectioned serially, while only a portion of the larger gonads were sectioned. Routine fixing, embedding and staining methods were employed, and need not be described.

All drawings were made with the aid of a camera lucida.

OBSERVATIONS

Rat

Primordial germ cells in the 10 day embryo lie in the thin flat endoderm, ventral to the intermediate mesoderm and the paired dorsal aortae (plate I, fig. 1; table I). The endoderm forms a closed gut at 11 days, and primordial germ cells are contained in its walls (see plate I, fig. 2; table I) from which they move, and are found at 11½ days in the mesenchyme between gut and splanchnic plate, and in the splanchnic plate (plate I, fig. 3; table I). The splanchnic mesodermal plates between the medially located coelomic angles and the junctures of nephrotomes and mesodermal plates now constitute the germinal epithelium. Between 11½ and 12 days most of the germ cells are found in the germinal epithelium and a few in the medulla (table I). For the first time, each germ cell in the splanchnic plate at 11½ days has its own follicle cell, which must have been acquired in traversing the splanchnic plate, since germ cells in gut and mesenchyme do not have them.

At 11 days, solid wolffian ducts lie lateral to and separate from the nephrotomes (plate I, fig. 2). Between 11½ and 12 days the remaining intermediate mesoderm breaks up into a mesonephric blastema, which is concentrated between the wolffian ducts (now with lumina) and the root of the dorsal mesentery (plate I, fig. 4). By the 13th day the lateral portion of the blastema differentiates into mesonephric tubules with lumina, while other portions extend dorsomedially to form the rudiments of the adrenal cortex. At 13½ days vasa efferentia project from cephalic segments of the rete blastema toward the mesonephric tubules (plate I, fig. 5).

As shown in table I, the number of germ cells in the thin germinal epithelium at 13 days is about the same as at 12 days, while there has been an enormous increase in the number of germ cells in the medulla. Few or no germ cells remain in the dorsal mesentery at 13½ days, and the number in the germinal epithelium has decreased, while more are found in the medulla (table I). In all three places, germ cells still retain one follicle cell each.

Sex can be diagnosed by the 14th day on the basis of germ cell counts. One 14 day specimen showed 63 germ cells (8% of the total) in the germinal epithelium and 753 (92% of the total) in the medulla. Another 14 day specimen had 16 (2%) in the germinal epithelium and 834 (98%) in the medulla; while a third had no germ cells in the germinal epithelium and 732 (100%) in the medulla (table I). Evidently depletion of the cortex signifies a testicular trend of differentiation. Almost every germ cell lying in medulla or cortex of more distinctly female specimens is seen to have a follicle cell closely applied to its surface. (Sections in which germ cells do not show attached follicle cells are undoubtedly cut at angles which do not show the follicle cells.) In 14 day males, follicle cells have fallen away from most of the germ cells. This is another indication of sex differentiation. Morphological evidence of sex differentiation becomes more obvious at 14½ days when, in males, stroma cells move from medial and lateral sides of the hilum toward the crest of the gonad to form the primary albuginea, separating, now broadly, the cortex from the medulla. At 15 days the tunica is thick and vascular, and the germinal epithelium has become quite thin. A few germ cells (still with attached follicle cells) remain in the tunica in the cephalic part of the gonads. Otherwise all of the germ cells lie in the medulla (table I).

Seminal tubules, at sex differentiation, are formed by partitioning of the medulla by mesenchyme (plate I, fig. 6). In them the follicle cells have lost their close connection with the spermatogonia and are scattered throughout the tubules.

The ovaries likewise appear clearly differentiated at 15 days. They consist of a greatly thickened cortex, and a medulla, the two separated by a very thin tunica (plate I, figs. 7 and 8). Nearly equal numbers of germ cells lie in medulla and cortex (table I). The ovogonia in the cortex, tunica and medulla still retain their individual follicle cells.

Adrenal cortical rudiments have separated completely from the mesonephric blastema at 14 days, and sympathetic ganglia cells are moving ventrally toward the cortical blastema to form the adrenal medulla.

Interstitial cells appear in the testis at sex differentiation. The rete blastema at the hilum of the 16 day embryonic testis is diffuse where it joins the intertubular tissue. This suggests the possibility of the blastemal origin of the interstitials.

At the 15th day the rete ovarii and rete testis are morphologically alike; and in both sexes vasa efferentia connect with mesonephric tubules.

The müllerian ducts are first seen at 14 days as grooves in the cephalic part of the urogenital ridges, ventrolateral to the wolffian ducts. At 15 days the müllerian ducts have sunken in from the surface and have become solid strands of cells, caudad of the open ostia.

The following descriptions are of ovarian changes only, since changes occurring in the testis after sex differentiation are less drastic than those in the ovary, and may be followed in table II.

About the 18th day of embryonic life the cortex becomes divided by mesenchyme into small masses consisting of germ and follicle cells. In the deeper layers of the cortex the germ cells begin to undergo prematuration changes. As a result, ovocytes (synaptene stage) are more conspicuous in this inner zone (plate I, fig. 9). By 20 days most or all of the germ cells of the cortex have become ovocytes, i.e., are in prematuration stages (plate I, fig. 10).

At the 21st day the cortex consists of irregular egg-cords, radiating peripherally from the inner edge of the cortex. In most of the egg-cords, follicle cells are arranged in a single layer around each ovocyte, the stroma is growing into the cords, cutting them up into smaller groups of ovocytes and primary follicles. One day later (at birth) primary follicles are scattered all along the inner edge of the cortex (plate II, fig. 11) and by 5 days postpartum fragmentation of the egg cords into primary follicles is practically complete (plate II, fig. 12). At 10 days postpartum some of the follicles show antrum formation (plate II, fig. 13).

At 10 days postpartum strands of large cells grow from the epoöphoron toward the periphery of the ovary and apparently scatter between the primary follicles near the surface. These cells are probably forerunners of the theca interna cells (plate II, fig. 15). Part of the rete blastema in the hilum forms the rete ovarii.

Principal changes undergone by testis and ovary after sex difdifferentiation may be followed in table II.

Pig

In the youngest embryos studied (6 mm.) mesonephroi are well-developed, while germinal ridges consist merely of strips of cuboidal epithelium on the medial surfaces of the mesonephroi, and of a thin medulla located between the thickened epithelium and the medial walls of the renal corpuscles. Germ cells are found in germinal epithelium and medulla, and also embedded in the mesenchyme of the root of the dorsal mesentery (plate II, fig. 16). Counts of germ cells in one specimen showed, in 50 consecutive sections, 4 (11%) in the dorsal messentery, 24 (65%) in the germinal epithelium and 9 (24%) in the medulla (table I). In slightly older embryos (8 to 12 mm.) no germ cells are found in the dorsal mesentery (table I); otherwise the germ cell ratios remain about the same. In most cases each germ cell has an individual follicle cell closely applied to its surface.

Increase in gonad volume begins at 13 to 15 mm. The germinal epithelium remains thin and the medulla is divided into irregular masses by fine fibers (plate II, fig. 17). There has been a great increase in the number of germ cells in the medulla (table I). Just dorsal to the root of the mesentery lie the paired adrenal cortex primordia which are still continuous with the gonadal rete cords.

Sex differentiation occurs in 20 to 25 mm. embryos. In testes the germinal epithelium becomes very thin and devoid of germ cells. In the thick vascular tunica albuginea many germ cells may still be found. The seminal tubules are small and form a network (plate II, fig. 18a). In 20 to 25 mm. females, 8% of the germ cells are in the cortex and 92% in the medulla; while in males of the same stage, all of the germ cells lie in the albuginea or within the medulla. In the ovary at sex differentiation the germinal epithelium becomes rapidly thicker and the primary tunica is less sharply defined than in the testis (plate II, fig. 20a).

At this stage, other derivatives of the mesonephric blastema become more evident. Adreno-cortical primordia separate from the parent blastema, and in the cephalic part of the gonad ridge, cord-like vasa efferentia reach from the rete blastema toward the renal corpuscles. At the level of the rete, especially at the hilum, large round cells occur between the seminal tubules which may represent young stages of interstitial cells. (This is essentially as described in Ancel and Bouin, 1903.) From this time on, interstitial cells increase in number.

In the testes at 35 to 38 mm. (plate II, fig. 19a) a higher percentage of the medullary germ cells are without follicle cells, indicating that in the testis, follicle cells leave the germ cells to form Sertoli elements. In ovaries of the same age (plant II, fig. 21a) germ cells are found in both germinal epithelium and medulla. A high percentage of the cortical and medullary germ cells retain individual follicle cells.

Further development of the ovarial cortex is shown in plate II, fig. 22 and plate III, figs. 23 to 25.

Between 120 and 150 mm., just prior to the segregation of the primary folicles from egg cords, ovarian follicle cells divide and become arranged in a single layer around each germ cell to form the granulosa layer.

Development of testis and ovary from sex differentiation to birth may be followed in table III.

Cattle

The genital ridge at the 6 mm. stage is relatively poorly developed: the germinal epithelium is thin and the medulla is sparse and loose (plate III, fig. 26). At 9 mm. the germinal ridges consist of strips of thickened epithelium on the ventromedial surfaces of the mesonephroi, underlain by shallow and densely packed medullae (plate III, fig. 27). The same proportion of germ cells is seen at 9 mm. as at 6 mm., in the dorsal mesentery, germinal epithelium and medulla (table I).

The enlarging gonads bulge into the coelom at 11½ mm. The germinal epithelium thickens, then begins to thin out at 16 and 20 mm. The dense medulla fills the core of the germinal ridge, and at 16 mm. becomes divided into cell masses by fine fibers of stromal origin (plate III, fig. 29). At 20 mm. the medulla is separated from the germinal epithelium by a cellular and fibrous tunica albugiea. At 11½ mm., 61% of the germ cells are found in the germinal epithelium and 39% in the medulla; none are left in the dorsal mesentery (table I). The gonads continue to increase in size and according to germ cell counts at 13 mm., some of the germ cells seem to shift from the germinal epithelium to the medulla (42% in the germinal epithelium, 58% in the medulla; table I). At 16 mm. a further shift of germ cells has occurred from the germinal epithelium to the medulla (11% in the germinal epithelium and 89% in the medulla; see table I).

At 20 mm. the corticoadrenal primordia have separated from the gonad medulla.

Sex differentiation begins at about the 25-30 mm. stage. In testes the germinal epithelium is very thin and sterile and is separated from the seminal tubules by a thick fibrous tunica albuginea which contains germ cells, while the ovary, smaller than the testis, retains a thicker germinal epithelium and has a less fibrous tunica, both structures containing germ cells. In testes shortly after sex differentiation, few germ cells (5%) remain in the germinal epithelium while 95% are found in the medulla. Large numbers are also found in the tunica. In ovaries at the same period there are found somewhat more germ cells in the germinal epithelium than in the medulla (57% in the germinal epithelium, 43% in the medulla; table I). The majority of the germ cells of the testes do not retain individual follicle cells, while in the ovaries most of the cortical and medullary germ cells retain them.

In the testis after sex differentiation, rete testis cells diffuse into the areas between the seminal tubules, and may give rise to large blastemic cells found between the seminal tubules—the precursors of the interstitial cells. The rete at 35 mm. is in the form of solid cords of cells and is connected through vasa efferentia to degenerating renal corpuscles and to mesonephric tubules. The remaining mesonephric tubules constitute the epididymis. In 60 mm. embryos the rete cells are beginning to form the rete cords.

After sex differentiation, changes undergone by the ovaries are more striking than those occurring in the testes. The cortex is divided into egg cords by the ingrowth of stroma of the primary tunica. Beginning at 110 mm., germ cells at the inner edge of the cortex begin to undergo prematuration changes. This zone of prematuration thickens at the expense of the outer ovogonial zone (plate III, fig. 31).

Follicle cells are arranged in one layer around each germ cell to form a granulosa layer. By 150 mm. a few primary follicles have appeared at the inner edge of the prematuration zone (plate III, fig. 32). By 520 mm. the cortex has been extensively invaded by connective tissue, and contains many degenerated primary follicles, besides a few normal primary follicles and sterile cords of cells (plate III, fig. 34). Follicles begin to grow again just before birth (900 mm.) (plate III, fig. 36), and a few atretic follicles are found at this time.

DISCUSSION

In vertebrates more primitive than amphibia (e.g. cyclostomes), sex glands consist of germ cells and germinal epithelia without mesonephric components (medulla, rete, vasa efferentia). The latter becomes added in some fishes, the amphibia and all higher forms.

Germ cells, in frogs, pass from the gut roof endoderm into the germinal epithelium (each germ cell receiving one follicle cell en route, Witschi 1914) and then, in males at sex differentiation, into the medulla. In the ovarian medulla, in the frog, no germ cells are received at any time (Witschi 1929); while in *Ambystoma tigrinum* (Gilbert 1940), reptiles (Allen 1906; Risley 1933), birds (Hoffmann 1892, Blocker 1933, Witschi 1935, and others) and in mammals (Vannemann 1917, Bookhout 1938, Rubaschkin 1910, 1912, Rauh 1929, and present investigation) both medulla and cortex of indifferent gonads contain germ cells.

Hargitt (1925, 1926, 1930) and Goldsmith (1932) state that, in the rat, extragonadal germ cells are not found, and that germinal epithelium somatic cells give rise to definitive germ cells. Hargitt apparently later modified his original stand, since two of his students, Bookhout (1937) and Kates (1937) state that in guinea pig embryos germ cells of extragonadal origin and some that arise from germinal epithelium cells are present in the gonads simultaneously. It is claimed that the former all degenerate. The author of the present paper has been unable to find evidence of transformation of somatic into germ cells.

In the rats differentiation of mesonephric tubules, adrenal cortical primordia and gonad rete blastema from mesonephric blastema all occur within a very short period of time, while in pigs and in cattle mesonephroi are differentiated from the blastema (earlier in pigs than in cattle) some time before the gonads arise.

At first sterile, the splanchnic mesoderm becomes a germinal epithelium when the germ cells enter it. At the time when the germ cells are first found in the germinal epithelium, the distribution of germ cells in 12 day rats is: 75% in the germinal epithelium, 24.9% in the medulla, including the albuginea, and 0.1% in the dorsal mesentery; in 6 mm. pigs: 65% in the germinal epithelium, 24% in the medulla and 11% in the dorsal mesentery; and in 6 mm. cattle: 46% in the germinal epithelium, 23% in the medulla and 31% in the dorsal mesentery.

Contrary to many earlier interpretations, the medulla does not arise as a "first proliferation", nor the cortex as a "second proliferation" from the germinal epithelium. In the testis the germinal epithelium thickens during early stages, then becomes thin. At sex differentiation, all of the germ cells in male rats, and most of the germ cells in male pigs and cattle move inward from the germinal epithelium. (In pigs and cattle some germ cells are caught in the tunica albuginea). These migrating germ cells (plus their follicle cells) move inward singly, not as cords. In ovaries the germinal epithelium thickens en masse to form the cortex, and only secondarily becomes divided into "egg cords" by growth of stroma of the primary tunica toward the surface of the gonad. Ovarian medullary cords in rats persist for a very short time, while in pigs and cattle they remain for a longer period, becoming more fragmented as development progresses. In 190 mm. female pigs and 100 mm. cattle, medullary germ cells begin to exhibit degenerative changes.

In males the formation of seminal tubules in situ from the medulla is similar in all three species. At first solid, the testicular medulla is divided into seminal tubules by the ingrowth of stroma. At birth, seminal tubules of all three animals look essentially alike. The individual tubules containing germ cells in central and peripheral positions, and Sertoli cells along the periphery.

In females, cortical transformations are alike in all three species. Germ cell maturation proceeds in a wave from the depth of the cortex toward the periphery. In the ovaries of rats at birth, primary follicles are just beginning to be cut off the inner edges of the egg cords, and have not yet begun to enlarge; in pigs at birth primary follicles are beginning to enlarge, but not all of the egg cords have entirely become divided into primary follicles; toward the periphery there remain egg cords containing ovocytes in the synaptene stage; in cattle, the ovary is more advanced at birth: some of the follicles are of considerable size and have large antra; follicular atresia is in progress.

The stage of development reached in the rat ovary at birth corresponds to stages attained in 150 mm. pig embryos and 150 to 200 mm. cattle embryos.

The origin and early development of the follicle cells is the same in rats, pigs and cattle. They arise from coelomic mesoderm. Counts of germ cells bearing individual follicle cells suggest that, in females, the germ cells retain their follicle cells which later multiply and form the granulosa layers of the primary follicles. In males, soon after sex differentiation the follicle cells fall away from the germ cells and become attached to the connective tissue of the seminal tubule walls to form Sertoli cells. This remarkable behavior of the follicle cells is a relatively recent sex characteristic; in amphibians the follicle cells remain directly associated with the germ cells until a late stage of spermiogenesis (Witschi 1924).

The rete testis and rete ovarii arise during sex differentiation in rats, pigs and cattle from the rete blastema, which in itself is a mesonephric derivative. From the rete blastema vasa efferentia grow out toward, and later connect with, the mesonephric tubules in rats, and with both mesonephric tubules and degenerating renal corpuscles in pigs and cattle. In testes of all three species, rete tubules form by the arrangement of rete blastema cells into cords which later acquire lumina, and remain near the hilum in rats, or penetrate into the center of the testis in pigs and cattle.

In all three forms tubuli recti grow from the rete and connect to the central ends of the seminal tubules.

The rete ovarii of rats, pigs and cattle consists of tubules in the hilum of the gland, and persist even in the adult. Some loose peripheral cells of the rete become scattered and their fate could not be ascertained.

The rete ovarii in the ovary of rats, 10 days postpartum, is seen to give off large cells which surround the primary follicles; these cells probably later form the theca interna of ovarian follicles. This was not observed in pigs and cattle, although such large cells were seen to be present. Kingsbury (1939), on the basis of his work on the cat, states that most of the evidence points to the theca arising by transformation of gonadal mesenchyme, but such transformations were not observed in the three forms studied here.

The origin of the testis interstitials was not clearly made out in the forms studied, but there were indications that cells of the rete testis are continuous with more cuboidal cells lying between the seminal tubules. Recent reviews state that testis interstitials most likely arise from gonadal mesenchyme. As in the case of theca interna cells, such transformations were not seen in the material at hand. It is necessary to emphasize that mesonephric blastema cells are scattered through the medulla and may be the source of many cell types usually attributed to mesenchyme.

While gonad development in amphibians and mammals follows essentially the same course, there exist some minor, but very characteristic differences: (a) Ovogonial mitoses and synaptic stages of ovocyte maturation are observed throughout the whole life in amphibians, but only prenatally in the rat, pig and cattle. (b) The theca interna of mammalian ovaries corresponds to the theca externa of the frog. (c) The participation of the medullary cords in the formation of the follicular theca is less obvious in mammals than in amphibians. (d) The follicle cells fall away from the spermatogonia and become sustentacular cells soon after sex differentiation in the mammalian embryo; the same transformation occurs at a much later stage in amphibians.

SUMMARY

Comparative studies were made on gonad development in rats, pigs and cattle.

Primordial germ cells of the early rat embryo first lie in the endoderm, then, when the gut forms, in the gut walls. Cell counts at various stages prove that the germ cells move from gut endoderm to the dorsal mesentery (where each germ cell acquires one follicle cell), and into both medulla and germinal epithelium (the base of the latter being the splanchnic mesoderm between the root of the dorsal mesentery and the place of attachment of the nephrotomes). In the youngest cattle and pig embryos available, most of the germ and follicle cells were found in medulla and germinal epithelium of the sex glands, and a few still in the dorsal mesentery.

In the rat, nephrotomes give rise to the wolffian ducts. The remainder becomes mesonephric blastema, out of which arise mesonephric tubules, adrenal cortex and gonad medulla.

Germ cell counts indicate that, in males before and at sex differentiation, most of the germ cells move from the germinal epithelium into the medulla, each one retaining its follicle cell; in females, such migration, if it occurs at all, is much less extensive, and germ cells in the germinal epithelium become ova. In males, germ cells remaining in the periphery are trapped in the primary tunica albuginea, and apparently degenerate.

In the three investigated species, the germinal epithelium in males thickens in early stages, and later becomes thin. In females it thickens to form the cortex. The medulla plus its germ cells is divided by stroma into seminal tubules in males and medullary cords in females. In females the medullary cords fragment and the germ cells undergo degeneration and finally disappear.

In males, individual follicle cells leave their attachment to the germ cells. Germ cells later lie attached to the walls of the seminal tubules where they multiply, mature and become ripe spermatozoa. In females, cortical germ cells retain their follicle cells, which later form the granulosa layer. Egg cords are formed by the cutting up of the cortex by stroma; primary follicles are cut off the inner ends of these cords after the germ cells have undergone prematuration changes in a centrifugal wave.

The rete differentiates from a portion of the mesonephric blastema and in both sexes the vasa efferentia grow out from the rete

and connect with the mesonephric tubules. (The latter constitute the epididymis in the male, the epoöphoron in the female). In males the tubuli recti arise as growths from the rete toward the seminal tubules.

Müllerian and wolffian ducts are found temporarily in both sexes. In the male the müllerian ducts persist and the wolffian ducts disappear.

Theca interna cells (at least in the rat ovary) may arise from cells derived from the mesonephric blastema and surround the primary follicles.

In males, interstitial cell origin was not clearly ascertained, but evidence favors the mesonephric blastema as the source.

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EXPLANATION OF PLATES
ABBREVIATIONS

AD — Adrenal cortex
AT — Atretic follicle
C — Ovarian cortex
DA — Dorsal aorta
DF — Degenerated follicle
DG — Degenerated glomerulus
DM — Dorsal mesentery
E — Endoderm
EC — Egg cord
EP — Epoöphoron
G — Gut
GC — Primordial germ cell
GE — Germinal epithelium
GF — Growing follicle
I — Interstitials
M — Medulla
MB — Mesonephric blastema
MC — Mesenchyme
MD — Müllerian duct
MT — Mesonephric tubule
N — Nephrotome
OC — Ovocyte
OG — Ovogonium
PF — Primary follicle
R — Rete
S — Spermatocyte
SC — Sertoli cell
SPL — Splanchnic mesoderm
ST — Seminal tubule
SZ — Spermatozoön
TAI — Primary tunica albuginea
TAII — Secondary tunica albuginea
TI — Theca interna
VE — Vasa efferentia
W — Wolffian duct

PLATE I

Rat embryos. X170.

Fig. 1. 10 days. Primordial germ cells in endoderm.

Fig. 2. 11 days. Germ cells in gut wall. Wolffian ducts solid. Nephrotomes separated from somites.

Fig. 3. 11½ days. Germ cells moving from gut into germinal epithelium.

Fig. 4. 12 days. Nephrotome diffuse (mesonephric blastema). Germ cells in germinal epithelium. Mesonephric tubules forming from blastema. Wolffian ducts with lumina.

Fig. 5. 13½ days. Vasa efferentia growing from rete toward mesonephric tubules.

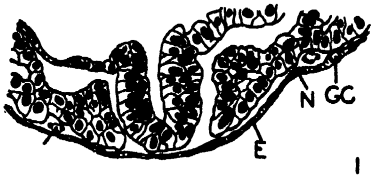
Fig. 6. 15 days. Testis. Tunica albuginea formed. Medulla dividing into seminal tubules. Vasa efferentia clearer. Solid Müllerian ducts.

Fig. 7. 15 days. Ovary. Tunica albuginea very thin.

Fig. 8. 16 days. Ovary. Primary tunica albuginea. Müllerian ducts with lumina.

Fig. 9. 18 days. Ovary. Egg tubes forming from cortex.

Fig. 10. 20 days. Ovary. All cortical germ cells ovocytes. Secondary tunica albuginea.



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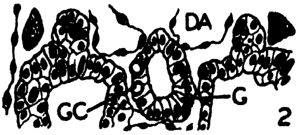

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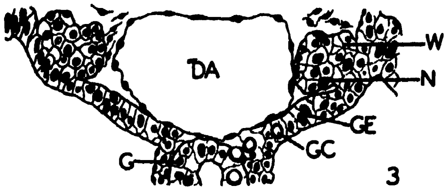

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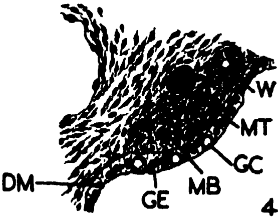

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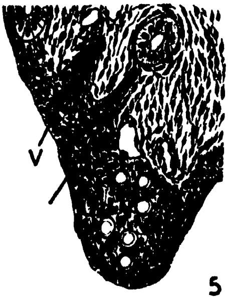

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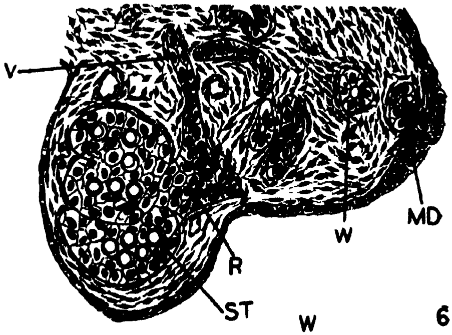

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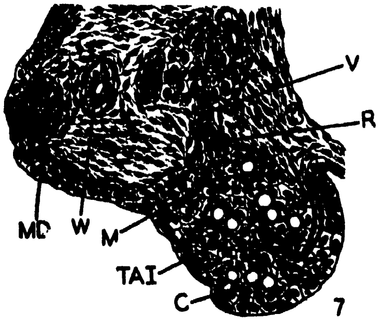

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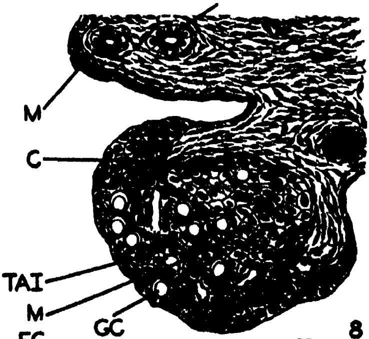

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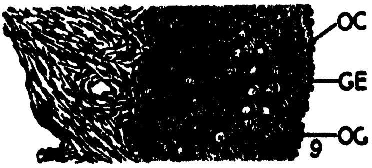

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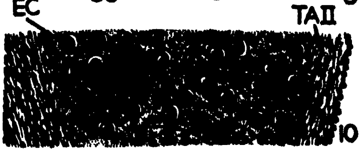

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PLATE II

Figs. 11-15, postpartum rats, X170. Figs. 16-22, pig embryos; all X170, except figs. 18, 19, 20 and 21 (diagrammatic.)

Fig. 11. Newborn female. Primary follicles appearing at inner edge of cortex.

Fig. 12. 5 days postpartum. Female. Increased number of primary follicles.

Fig. 13. 10 days postpartum female. Growing follicles, one with small antrum. Primary follicles and ovogonia in secondary tunica albuginea.

Fig. 14. 29 days postpartum female. Enlarged follicles with thick theca interna. One atretic follicle shown.

Fig. 15. 10 days postpartum female. Theca interna cells moving toward primary follicles.

Fig. 16. 8-10 mm. pig embryo. Germinal epithelium and medulla with germ cells.

Fig. 17. 15-20 mm. pig embryo.

Fig. 18. 20-25 mm. male embryo. Testis at sex differentiation.

Fig. 18a. Same. Part outlined in fig. 18, enlarged.

Fig. 19. 35-38 mm. male embryo.

Fig. 19a. Same. Part outlined in fig. 19, enlarged.

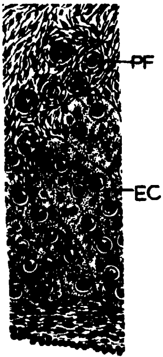
Fig. 20. 20-25 mm. female embryo.

Fig. 20a. Same. Part outlined in fig. 20, enlarged.

Fig. 21. 35-38 mm. female embryo.

Fig. 21a. Same. Part outlined in fig. 21, enlarged.

Fig. 22. 50 mm. female embryo. Part of ovary, showing cortex and medulla.



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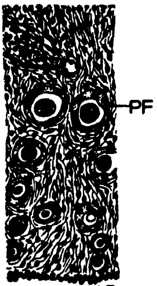

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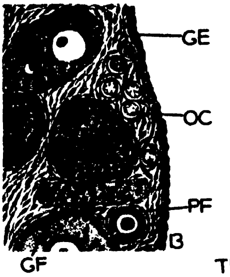

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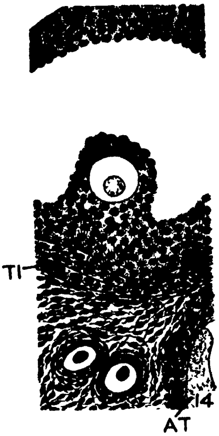

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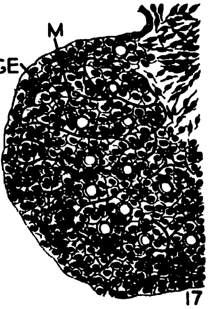

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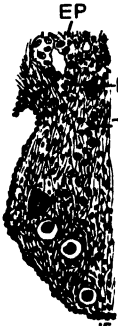

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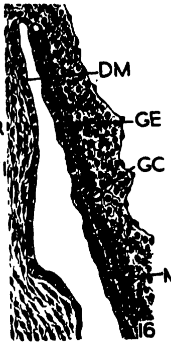

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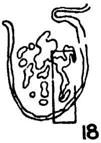

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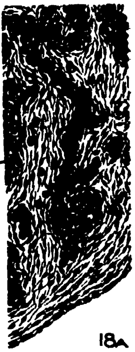

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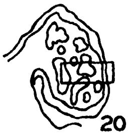

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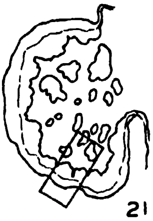

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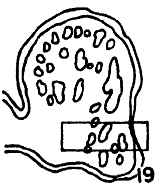

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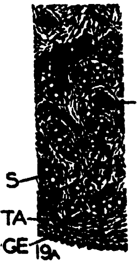

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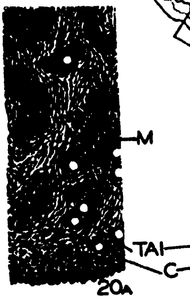

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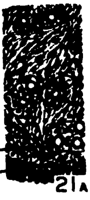

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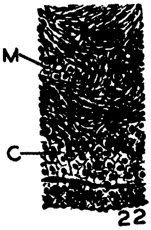

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PLATE III

Figs. 23-25, pig embryos, X170. Figs. 26-36, cattle embryos, X170, except fig. 35 (X70), and fig. 36 (X731).

Fig. 23. 90 mm. female. Egg cords beginning to form from cortex.

Fig. 24. 150 mm. female. Egg cords further differentiated. Few primary follicles at inner edge of cortex.

Fig. 25. 220 mm. female. Showing one follicle beginning to grow. Egg cords reduced in size.

Fig. 26. 6 mm. cattle embryo. Germ cells in mesentery and in medulla under thin germinal epithelium.

Fig. 27. 9 mm. cattle embryo. Germinal epithelium thickened.

Fig. 28. 13 mm. cattle embryo.

Fig. 29. 16 mm. cattle embryo. Medulla cut up by stroma. Thin germinal epithelium.

Fig. 30. 36 mm. female cattle embryo. Thick cortex. Wide secondary tunica albuginea. Medulla still large, solid.

Fig. 31. 110 mm. female cattle embryo. Many cortical germ cells in synaptene stage.

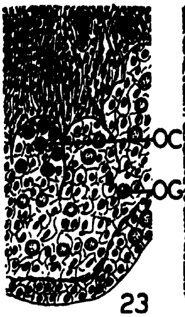
Fig. 32. 150 mm. female cattle embryo. Thin inner zone of primary follicles.

Fig. 33. 320 mm. female cattle embryo. Few small bundles of synaptene ovocytes remaining.

Fig. 34. 520 mm. female cattle embryo. Few degenerated primary follicles at inner edge of cortex. Enlarged primary follicles.

Fig. 35. 53 mm. male cattle embryo. Rete strands attached to degenerated renal corpuscles and mesonephric tubules.

Fig. 36. 900 mm. female cattle embryo. Cortex full of connective tissue. Primary follicle shown. Very thin germinal epithelium.



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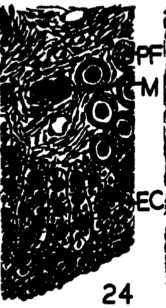

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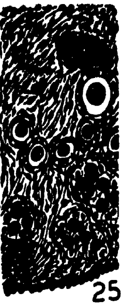

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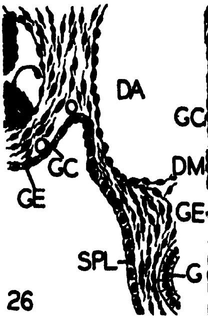

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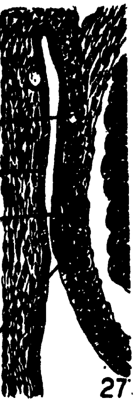

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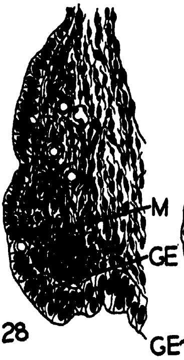

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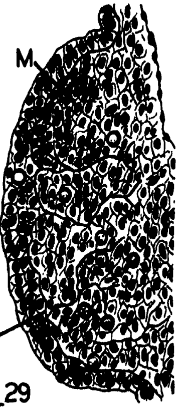

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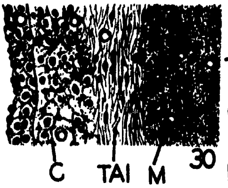

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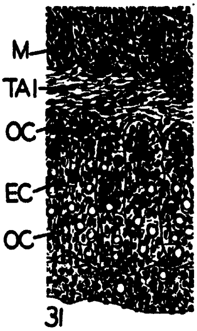

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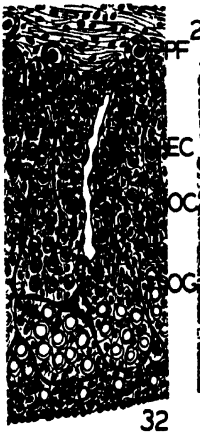

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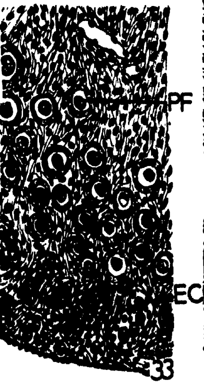

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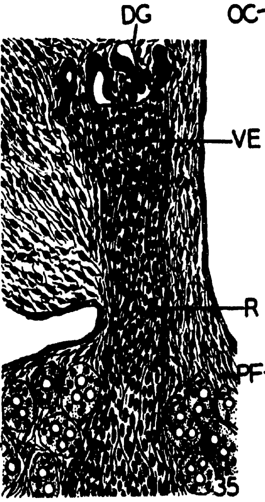

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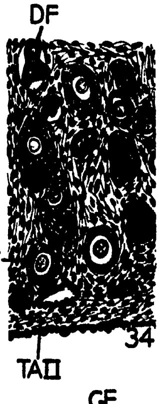

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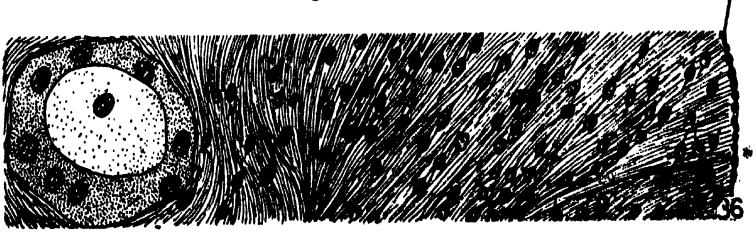

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TABLE I

GERM CELL DISTRIBUTION IN EARLY EMBRYONIC GONADS OF RAT, PIG AND CATTLE

				No. of germ cells in 50 consecutive sections							
Animal	Age (da.)	Sex	C.-R. length (mm.)	Gut end.	%	D. Mes.	%	Cortex	%	Med.	%
Rats	10	----	1.3	18	100	----	----	----	----	----	----
	11(a)	----	4.0	63	100	----	----	----	----	----	----
	11(b)	----		16	100	----	----	----	----	----	----
	11½	----	3.8	26	42	36	58	----	----	----	----
	12	----	4.2	----	----	8	0.1	66	75	14	24.9
	13(b)	----	6.4	----	----	----	----	50	22	174	78
	13(A″)	----		----	----	7	2	87	25	255	73
	13½(1)	----	7.2	----	----	----	----	36	9	358	91
	13½(2)	----		----	----	10	3	47	12	325	85
	14 (b)	----	8.8	----	----	----	----	63	8	753	92
	14 (d)	----		----	----	----	----	16	2	834	98
	14 (c)	----		----	----	----	----	----	----	732	100
	15 (a)	♀	11.0	----	----	----	----	680	50	679	50
	15	♀		----	----	----	----	920	55	747	45
	15	♂		----	----	----	----	----	.	all	100
Pigs			6	----	----	4	11	24	65	9	24
			8-12(1)	----	----	----	----	31	60	21	40
			8-12(2)	----	----	----	----	38	58	27	42
			13-15	----	----	----	----	61	18	273	82
			15-18(1)	----	----	----	----	69	21	258	79
			15-18(2)	----	----	----	----	42	11	321	89
		♀	20-25	----	----	----	----	47	8	506	92
		♂	20-25	----	----	----	.	----	----	675	100
Cattle			6	----	----	5	31	10	46	7	23
			9	----	----	18	37	20	42	11	21
			11½	----	----	----	----	17	61	11	39
			13	----	----	----	----	21	42	29	58
			16	----	----	----	----	17	11	140	89
		♀	28	----	----	----	----	154	57	114	43
		♂	30	----	----	----	----	16	5	390	95

TABLE II

DEVELOPMENT OF RAT GONADS

Age (da.)	C.-R. L (mm.)	Sex	No.	Mesonephroi and Ducts	Germ Cells	Germinal Epithelium (Cortex)	Medulla	Follicle & Sertoli Cells	Rete	Inter-stit-ials
11	1.4	....	1	W.d.	In gut	Thin	....	....	....	....
11½	3.3	....	1		In gut & d. mes.			....	....	....
12	4.2	....	1	Tubules	In d. mes., g ep., medulla		Loose blastema. G.c.	....	....	....
13	6.4	....	2		In g. ep. & med.			On g.c. in g. ep. & med.	....	....
13½		....	5	Post. tub. degen.			Blastema concentrated		V. eff.	....
14	8.8	♂	2	W.d. & M.d.	Few in g. ep.					....
14		♀	1	As in ♂	Many in g. ep.					....
15	11.0	♂	3		In sem. tub.	Thin	Sem. tub.			....
15		♀	4		In cortex	Thick				....
16	13.0	♂	5	Lumina in M.d. & W.d.	Thruout sem. tub.			At periph. of s.tub.		Present
16		♀	1	As in ♂						....
18	19.7	♂	2	Epid. M.d. degen.					V. eff. connect to epid.	Large masses
18		♀	2	Large M.d.	Premat. stages	Divided	Reduced		V. eff. connect to epoö.	....
19	22.5	♂	2	W.d. only						
19		♀	1	M.d. only			....			....
Newb.	40.0	♂	1		At periph. of sem. tub.					
Newb.		♀	2		Primary foll.					
5 d.pp.	45.0	♀	1		Mostly prim. foll.			Foll. cells form		....
10 d.pp.	75.0	♀	1		Most foll. with antra		....			....
16 d.pp.	80.0	♂	1		Spermatocytes					
29 d.pp.		♂	1				Lumina in sem. tub.			
29 d.pp.		♀	1		Some atretic foll.		....			....
36 d.pp.		♂	1		Spermatids					
51 d.pp.		♂	1		Spermatozoa					

ABBREVIATIONS

abund.—abundant
corp.—corpuscle
cort.—cortex
degen.—degenerated
devel.—developed
d.mes., dors. mes., dors. mesent. —dorsal mesentery
epid.—epididymis
epoö.—epoöphoron
foll. c.—follicle cell
g. c.—germ cell
g. ep.—germinal epithelium
irreg.—irregular
med.—medulla
M.d.—müllerian duct
periph.—periphery
premat.—prematuration
prim.—primary
sem. tub., s. tub., s. t., sem. t. —seminal tubule
Sert. c.—Sertoli cell
Tub. recti—tubuli recti
T. alb. II—secondary tunica albuginea
V. eff.—vasa efferentia
W.d.—Wolffian duct

TABLE III
DEVELOPMENT OF PIG GONADS

C.-R. L. (mm.)	Sex	No.	Mesonephroi & Ducts	Germ cells	Germinal Epithelium (Cortex)	Medulla	Follicle & Sertoli Cells	Rete	Interstitials
6	....	1	W. d.	In g. ep., dors. mesent. & med.	Thin. Cuboidal.	Dense. G.c.	Foll. c. on g.c.	....	....
13-15	....	6			Thin. Columnar.	Divided			...
20-25	♂	5	W.d. & M.d.	In med.	Very thin	Irreg.		V. eff.	Scattered.
20-25	♀	3	As in ♂		Thicker than ♂	As in ♂		....	....
35-38	♂	6		In walls & center of sem. tub.		Sem. tub. regular.	Sert. c. scattered.	Rete & fibers	Abund.
35-38	♀	2		In cortex & med.		Fragmented.			
62-68	♂	2	Degen. begins	Most at periph. of sem. tub.			Sert. c. at periph. of sem. tub.	V. eff. connects to epid.	Strands & masses
62-68	♀				Irregular				....
85-95	♂	4							Large masses
85-95	♀	4		Few premat. g.c. deep in cortex		Scattered. T. alb. II			....
120-140	♂	10	Epididymis					Tub. recti. connect to s. tub.	
120-140	♀	4		Thick zone of premat. stages					....
150	♂	1						Lumina	
150	♀	2		Prim. foll. at inner edge cortex. Thick premat. zone			1 layered granulosa.		....
190	♂	1		Most at periph. of sem. tub.					
190	♀	1	M.d. convoluted	Foll. zone thicker.		Reduced further			
250	♂	1					1 layer of Sert. c. at periph. of sem. tub.		
260	♀	2	M.d. large	Few degen. prim. foll. at central edge of cortex					....

TABLE IV

DEVELOPMENT OF CATTLE GONADS

C.-R. l. (mm.)	Sex	No.	Mesonephroi & Ducts	Germ Cells	Germinal Epithelium (Cortex)	Medulla	Follicle & Sertoli Cells	Rete	Inter-stit-ials
6	....	1		In dors. mesent., g. ep., & med.	Cuboidal	G. c. & foll. cells.	One foll. c. per g. c.	....	....
9	....	2	Well devel. mesoneph.		Columnar			....	....
11½	....	2		In g. ep. & medulla	Thicker			....	....
16	....	1		More in medulla		Divided		....	....
25	♂	3	M.d. & W.d.	In med. & g. ep.	Very thin	Sem. tub.			Between s. tub.
28	♀	1	Like ♂ 25 mm.	Like 25 mm. ♂	Thicker than ♂			....	....
30	♂	1	Degen. begins					....	
36	♂	1					Few foll. c. on g. c.		
45	♀	2			Thicker			....	....
53	♂	1	Epid. M.d. small, solid	Throughout s. t.	Thin. No g. c.	Sem. tub. well-devel.	Thruout sem. t.	V. eff. connects to renal corp. & tub.	
60	♂	2	No M.d.					Cords	Strands & masses
110	♂	2	W.d. only			G. c. at periph. of sem. tub.	Sert. c. at periph. of sem. t.		
110	♀	2	M.d. only	Thin premat. zone at inner edge of cortex.		Fragmented			....
140	♂	2						Tub. recti connect to s.tub.	
150	♀	3		Few prim. foll. at inner edge cort. Thick premat. zone.				Lumina	....
220	♀	3		Thick zone prim. foll.		Few small clumps.	One layer granulosa.		....
320	♀	1		Prim. foll. zone thicker				Large	....
520	♀	1		Most pr. foll. degen.	G. ep. thin sterile	....			....
900	♂	1				Solid s. t.			Large masses
900	♀	1		Few foll. with antra					

NATURE OF *EIMERIA NIESCHULZI*-GROWTH PROMOTING POTENCY OF FEEDING STUFFS.
4. RIBOFLAVIN AND NICOTINIC ACID

Elery R. Becker

Observations on the effect of certain vitamins on the multiplication of *Eimeria nieschulzi* in its rat host have indicated that under certain conditions the infection may be significantly modified by feeding these materials. Vitamin B_1 had a moderately restraining effect on the development of the parasite, vitamin B_6 strongly enhanced its growth, while the two vitamins fed together limited its increment considerably more stringently than vitamin B_1 alone (Becker and Dilworth, 1941). Pantothenic acid, like vitamin B_6, enhanced the coccidium-growth-promoting potency of the otherwise unsupplemented ration, and neutralized the growth-inhibiting properties exhibited by the combination of vitamins B_1 and B_6 (Becker and Smith, 1942). The present study on the effects of riboflavin and nicotinic acid supplements to a particular ration were made in further prosecution of the general problems.

Procedure. Details relating to material and methods have been fully described elsewhere (Becker and Dilworth, 1941), but a few of the more pertinent are herewith repeated. The hosts were "Wistar A" white rats, raised free from coccidial infection and started on the experimental rations when of about 70 grams. On the tenth and twelfth days each rat was innoculated through a stomach tube with an estimated 3000 sporulated oocysts of *Eimeria nieschulzi.* Elimination of oocysts commenced about 7 days later and continued for about 6 days. During this period the droppings were collected, and the number of oocysts estimated by a dilution method. The numbers appearing in the table thus represent an estimation of the number of oocysts eliminated during such an experimental infection. The rats were practically immune to *Eimeria nieschulzi* when elimination of oocysts ceased. The control ration was made up in parts by weight as follows: beet sugar, 69; fine cellulose, 2; medium fine unextracted (crude) casein, 10; soy bean oil meal, expeller process, 10; normal salt mixture (Harris), 4; cod liver oil, 2; lard, 3.

TESTS WITH NICOTINIC ACID

Nicotinic acid was thoroughly mixed with the control ration in the proportion of 1:10,000. The vitamin was a synthetic product marketed in powder form.

The results of the experiment appearing in Table 1, involving in all 11 rats on the control ration and the same number on the supplemented ration, show quite definitely that the vitamin was without effect on the oocyst count. The counts of tests and controls in the two groups, viz., 178.6 and 177.2 millions, and 225.8 and 205 millions, respectively, are unusually close and make it appear that further tests would be unwarranted. The rats receiving nicotinic acid out-gained the controls in weight, but since to what extent rats utilize this vitamin is still undetermined, it is unsafe to draw conclusion on this point from so few experiments.

Table 1. Mean oocyst counts and weight gains for 2 groups of rats receiving control ration and for test rats receiving same mixed with nicotinic acid.

	Group 1		Group 2	
	Oocysts (millions)	Wt. gain (gm.)	Oocysts (millions)	Wt. gain (gm.)
Controls	178.6 (5 rats)	15	225.8 (6 rats)	22
Nicotinic acid recipients	177.2 (5 rats)	22	205 (6 rats)	28

TESTS WITH RIBOFLAVIN

The riboflavin used in these experiments was a synthetic crystalline product manufactured by a reputable and nationally known drug concern. The daily dose of 20 μ per rat was administered through a stomach tube, in 1 c.c. of water. It seemed to have little or no effect on the growth of the rat during the time required by the experiment, a result which would probably be expected since crude casein, which was used in the counted ration, is known to contain large amounts of riboflavin.

Since the object of the experiment was to determine whether the control series or the test series would eliminate the larger number of oocysts, a number of groups including both controls and tests were utilized in the experiment. The results, appearing in Table 2, show that in every one of five groups the riboflavin recipients eliminated fewer oocysts than the controls. The probability of obtaining 5 positives in 5 tests with chances equal is .031, a figure which indicates that we may have found a significant difference in the two series. When the differences of the five means are treated statistically according to the paired sample method (Fisher, 1930) a P-value less than .01 is obtained, so that the difference between the results is clearly significant.

Conclusions

1. Riboflavin supplements to the ration definitely curbed the multiplication of *Eimeria nieschulzi* in its host when numbers of oocysts eliminated were used as the measure of the parasite's increment.
2. Nicotinic acid appeared to be without effect on the multiplication of the coccidium, at least in the ration employed.

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Literature Cited

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Table 2. Mean oocyst counts and weight gains for 5 groups of rats receiving control ration and for test groups receiving 20μ riboflavin daily per rat.

	Group 1		Group 2		Group 3		Group 4		Group 5	
	Oocysts (millions)	Wt. gain (gm.)	Oocysts (millions)	Wt. gain (gm.)	Oocysts (millions)	Wt. gain (gm.)	Oocysts (millions)	Wt. gain (gm.)	Oocysts (millions)	Wt. gain (gm.)
Controls	25.3 (3 rats)	19	20 (4 rats)	24	28.8 (4 rats)	20	63 (4 rats)	21	81 (2 rats)	18
Riboflavin recipients	14.7 (3 rats)	25	15.5 (4 rats)	20	13.8 (4 rats)	23	47.3 (4 rats)	23	67 (3 rats)	21

THE MOUTH PARTS OF THE FIREBRAT, THERMOBIA DOMESTICA (PACKARD), (THYSANURA).

Roberta O'Harra and J. Alfred Adams

The purpose of this paper is to present detailed drawings of the external form of the mouth parts of the adult firebrat, as a representative lepismatid. That the Lepismatidae, or silverfish insects, are of great significance in insect morphology, is well known to students of the subject. In certain respects they are the principle morphological link between the Apterygota and the Pterygota. While any of the widely distributed, domestic species of *Lepisma* or *Ctenolepisma* might well be used for morphological study, the firebrat, *Thermobia domestica,* is the species which seems to us the most likely to be practical for use in experimental biology, largely because it is thermophilic and can be reared comparatively quickly at high constant temperatures (Adams, 1933, 1936; Sweetman, 1938). This insect has been used successfully in a series of toxicological studies carried on at Iowa State College: one of the more recent of these is an investigation of the toxicity of barium compounds (Richardson and Seiferle, 1941). The morphology of this insect, including the structure of its mouth parts, is likely to be of interest to a considerable variety of workers.

No detailed drawings of the mouth parts of the firebrat are known to us. Spencer (1924), at the University of Illinois, filed a thesis containing detailed drawings of this insect, but his work has remained unpublished.

Materials and Methods

The specimens used were reared in a culture which has been maintained continuously since 1931 without the introduction of new stock. The present rearing chamber is similar to the thermal gradient box elsewhere described (Adams, 1937). Whole specimens were studied alive, etherized, and in balsam mounts. Detached parts were fixed and mounted, usually by the use of acetic acid and clove oil as described by Britten (1930). Some specimens were briefly boiled in caustic and others were fixed in Bouin's fluid and sectioned. Owing to the fragile nature of the material it was usually necessary to make composite drawings from several specimens. Because of their larger size, females were studied most; but sex differences in the mouth parts, if constant, appear to be very slight. As an aid in the preliminary study a clay model of the head was made.

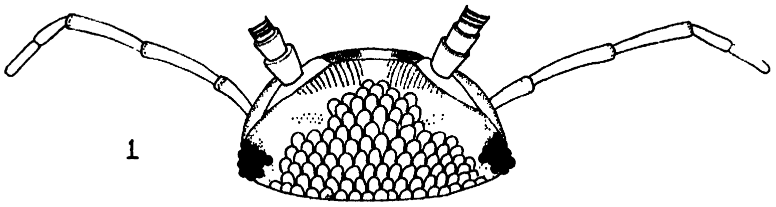
Features which are entirely evident from the drawings or have already been adequately described by Escherich (1905) or others, may not be discussed. The terminology is mostly that of Snodgrass (1935).

General Features of the Head

In the full-grown firebrat the breadth of the head including the eyes (about 1.6 mm.) is roughly twice as great as the length (about 0.8 mm.). In the living animal, the broad, and almost straight, posterior margin of the head is closely applied to the thorax. The vertex, which is weakly convex transversely, is strongly convex longitudinally and has a rather abruptly curved occipital rim which overhangs the cervical membrane (Figs. 8A-D).

Projecting forward over the occiput, and further protecting the cervical membrane, is a row of strong setal bristles on the anterior margin of the first thoracic tergite. The occiput is clothed with flat scales which extend forward in the form of a triangle, with the apex well behind the epistomal suture. These scales are anteriorly directed and vary in color so as to form a pattern harmonizing with that on the thorax.Perhaps the most striking feature of the head, as seen dorsally, is the presence of strongly developed systems of setal bristles around the eyes, on the discal and frontal regions of the vertex, and on the right and left thirds of the clypeus. These bristles, which usually have a pinkish tinge, have to be removed before examination of the head sutures is possible. The convex surface of the body of the mandible can then be seen from above, just ventral to the triagular antennal sclerites (Fig. 1).

The ventral, or oral, surface of the head is well provided with setal bristles on the labrum, mandibles, and labium. The difficulty of ventral examination is caused mainly by the dense whiteness of the inner tissues and the colorless, semi-transparent condition of the cuticula. The face is structurally dominated by the large mandibles, whose dark and heavily sclerotized tips are visible through the transparent labrum. In Fig. 2 the mouth parts are represented as slightly retracted from the pre-oral cavity in order to reveal the tip of the hypopharynx. When the pre-oral cavity is closed, the space between the lower margin of the labrum and ligulae is



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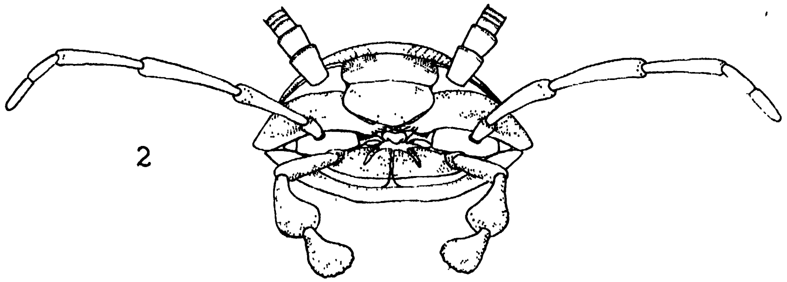

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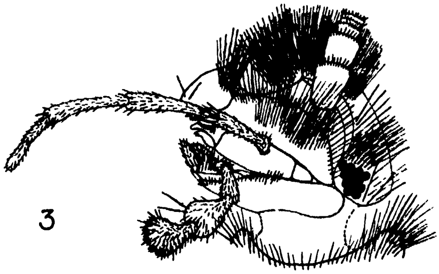

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Plate One

Fig. 1. Dorsal view of the head of the firebrat. The dots represent the sockets of setal bristles. Only the basal segments of the antennae are shown. Scales of antennae omitted.

Fig. 2. Ventral view of the read. Setal sockets shown by dots.

Fig. 3. Left lateral view of the head, with setal bristles, extended cervical membrane, and the anterior margin of the prothorax, included. Scales of the vertex omitted.

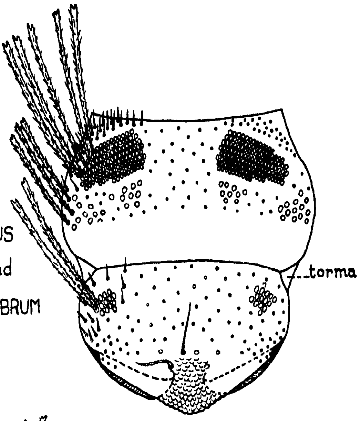
Plate Two

Fig. 4. Clypeus and labrum of firebrat, exterior or anterior view. Setal sockets shown; most of the setae omitted.

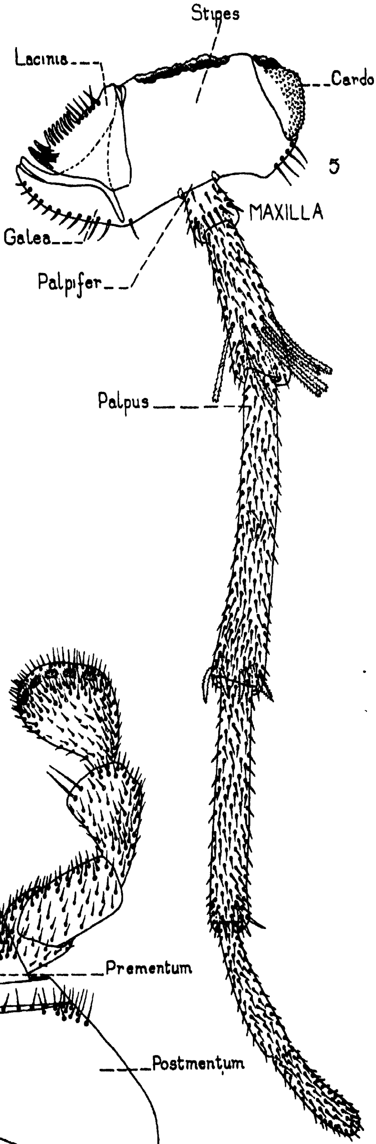
Fig. 5. Right mandible, external, or anterior, surface view. Setal sockets shown; most of the setae omitted.

Fig. 6. Left maxilla, internal view; with setae. The ventral edge is turned uppermost in the drawing.

Fig. 7. Labrum, anterior view. Setae shown only on left side of the drawing. Infolded membranes shown on left by dotted lines. Postmental scales omitted.



4
CLYPEUS
and
LABRUM



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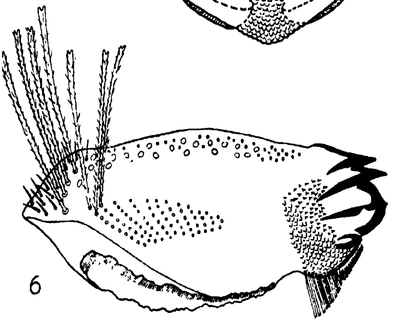
MAXILLA



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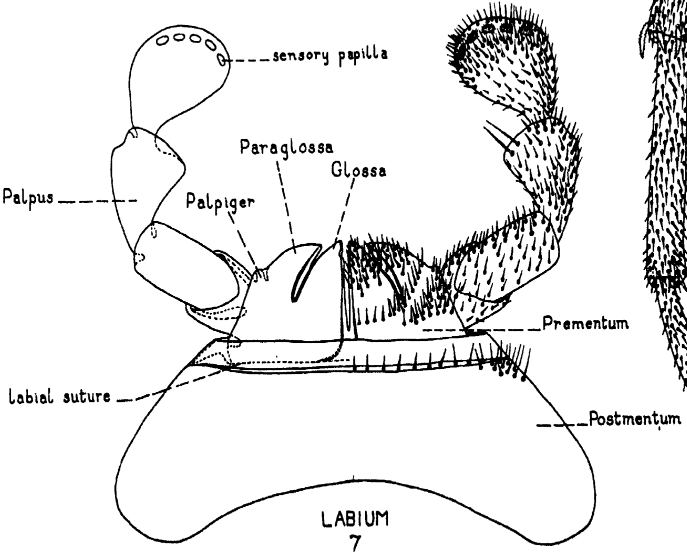
MANDIBLE



LABIUM
7

Plate Two

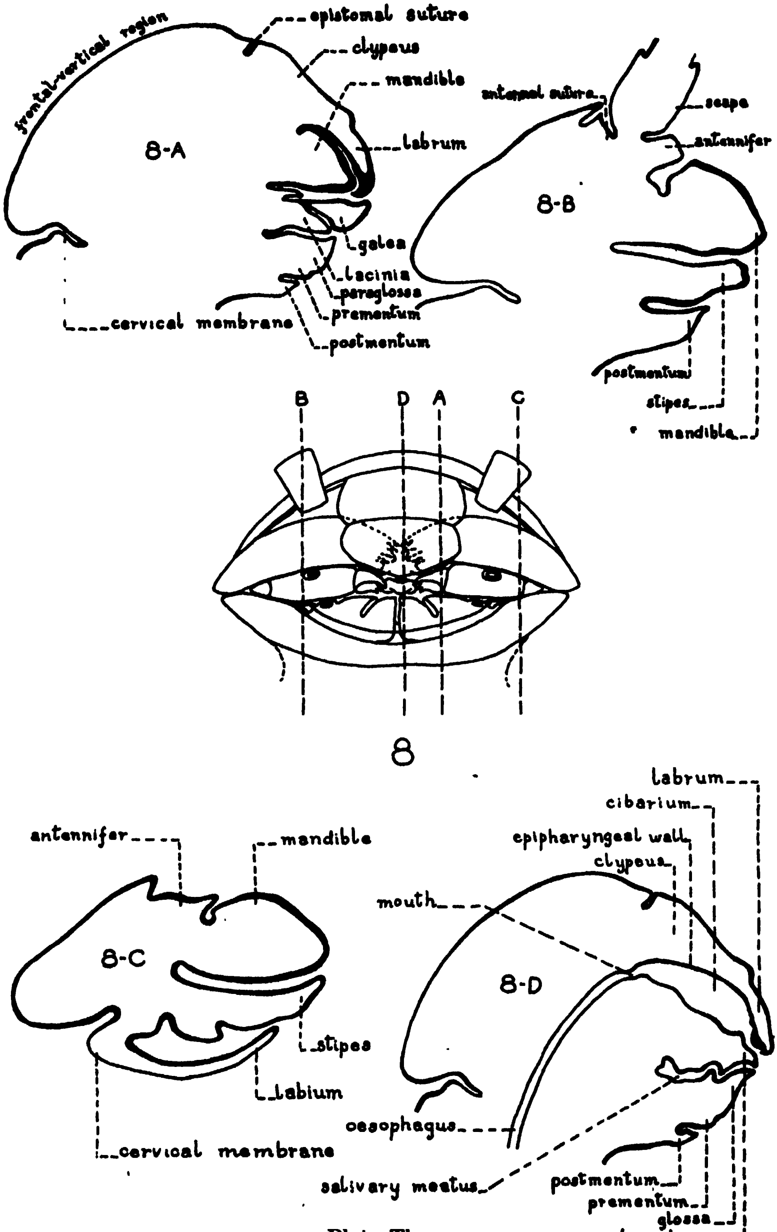


Plate Three

Fig. 8. Diagram of the ventral view of the head of the firebrat to show the planes of sagittal sections, 8a-D. The bases of the palps are shown as ovals.

Figs. 8a-D. Sagittal sections made along planes marked by vertical lines on the central figure. Only the cuticular layer is shown.

completely filled by the galeae. The dark tips of the laciniae are visible through the semi-transparent galeae.

The ventro-posterior wall of the head is formed by the large, simple, weakly sclerotized postmentum.

The Labrum

Figs. 2 and 4 show the anterior view of the labrum with its setal bristles or their sockets. The central area above the tip is roughened by what appears to be a row of scale-like cuticular processes. A pair of membranous pockets, which project below the latero-ventral margins, appear to be produced by invagination of the epipharyngeal wall. When the pre-oral opening is closed, the medio-ventral edges of the mandibles fit into these pockets. This relationship is shown in Figs. 8 and 8A. The lateral corners of the pockets are distinctly brownish and are evidently slightly sclerotized.

The Mandibles

The mandibles of Lepismatidae are discussed in considerable detail by Escherich (1905, p.13), and their homologies are discussed by Snodgrass (1935, p. 133). Fig. 6 shows the exterior aspect of the right mandible as it appears when the mandible is removed and slightly rotated so that the ventral articulation is brought into view. Fig. 8 shows the arched form of the mandible and its relation to the epipharyngeal pockets of the labrum. The sagittal sections (Fig. 8 A, B, and C) show the sectional form of the mandible. As in other Lepismatinae, the upper two of the heavy, dark, medial teeth are sharply pointed and those located more ventrally are blunt. Ventral to the latter the medial edge bears a comb-like row of short, curved, cuticular processes, which are progressively longer ventrally. On the arched, medio-ventral edge are located about ten cleft, setal bristles, also graded in length. Just lateral to the teeth, on the anterior face of the mandible, is an area in which the surface is roughened by minute cuticular, spine-like and scale-like processes. Running the length of the dorsal surface are long, cleft, feathered setal bristles interspersed with small, naked, pointed setae. On the disc of the mandible is a homogeneous group of setal bristles arranged in diagonal rows.

The Maxillae

The cardo, which Escherich (1905) appropriately called the pivot, is roughened on its projecting, rounded surface with minute, cuticular spines. The stipes bears only a few setal bristles on the dorsal edge continuous with those of the galea. Its form in section may be seen in Figs. 8 A, B, and C. The palpus in full-grown individuals consists of six visible regions, the last two of which are separated by a constriction about the middle of the fifth segment. The palpus is remarkable for the variety of its setal bristles. The entire surface is clothed with small, naked setae, and the first and fourth are crowned by large bristles of the same simple, pointed type. At the distal end of the third segment there stand a few feathered, pointed, setal bristles. From the second segment extend several enormous bristles which are both cleft at the tip and feathered. The galea acts as a hood, arching over the lacinia and completely covering it from view when the pre-oral cavity is closed (Fig. 8A). The medial processes of the lacinia are strikingly analogous to those of the mandible, there being sharp sclerotized teeth dorsally, followed ventrally by a cuticular comb and a row of setae.

The Labium

The postlabium consists of a broad postmentum which is contiguous at its lateral edges to the cervical membrane and the occiput, as is shown in an extreme lateral section of the head (Fig. 8C). The surface is covered with delicate colorless scales. The suture between the postmentum and the prementum is invaginated; that is, the prementum is telescoped into the anterior border of the postmentum (Figs. 8A and D). On the ventral surface of the postmentum parallel to the enclosed suture is a strong transverse fold bearing a row of setal bristles, those near the midline being weak, those toward the sides progressively stronger.

The prelabium is plainly a paired structure. The prementum consists of right and left halves which give evidence of their evolutionary origin by being distinct sclerites joined only near their bases by a membrane. Small setae occur on the distal parts of each glossa and paraglossa. Two curved rows of bristles are characteristically visible in the living animal; one of these extends from the lateral margin at the base of the paraglossa to the base of the cleft between the glossae; the other, lying lateral and parallel to this row, extends from the palpiger region and forms the median side of a group of small setae.

The palpus consists of three distal lobes and a short scoop-shaped proximal lobe, the homology of which is not clear. Escherich (1905) regarded the labial palpus as including all four segments. Spencer (1924) regarded the shallow basal segment as a palpiger. The cylindrical second segment is deeply telescoped into this proximal segment (Fig. 7, left side). When the palpus is forcibly pulled from the prementum this proximal segment remains adherent to the palpus, which fact to us supports the view that it is part of the palpus; if this is the case, the slightly lobed side of the main body of the prementum may be termed the palpiger region. (See dotted lines in Fig. 7). Opposed to this view is the fact that the labial palpi of *Machilis* are clearly only three-jointed (Snodgrass, 1935, p. 149), there being an insertion of the palpus into a lobe of the prementum which might be homologous to the insertion of the second segment into the proximal segment in *Thermobia.*

The sub-terminal segment of the palpus always bears on its medial, arched surface two prominent setae. On the ventral edge of the rounded tip of the clavate, terminal segment are five so-called sensory papillae, which lie in a row and are covered with numerous minute setae. The papillae were noticed by Womersley (1928).

The form of the hypopharynx, which is fairly large but very weakly sclerotized, was not worked out completely. The organ is slightly tri-lobed, the lateral members being regarded as superlinguae, and it projects upon a muscular stem. The hypopharynx, like the other mouth parts, cannot be fully understood without a study of the musculature and other internal features of the head.

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A PECULIAR STAINING REACTION IN *EUGLENA RUBRA* HARDY 1911

LELAND P. JOHNSON

During experimental work in which routine temporary stains were applied to various species of Euglena, an unusual reaction was found to occur in *Euglena rubra* when subjected to Noland's 1928 stain and fixative.

Hardy (1911) described *Euglena rubra* as possessing red pigment granules, haematochrome, in addition to chlorophyll. The organism possesses a pellicle with discontinuous spiral striations and two types of cysts—a temporary thin-walled cyst and a more permanent thick-walled cyst (Johnson, 1939).

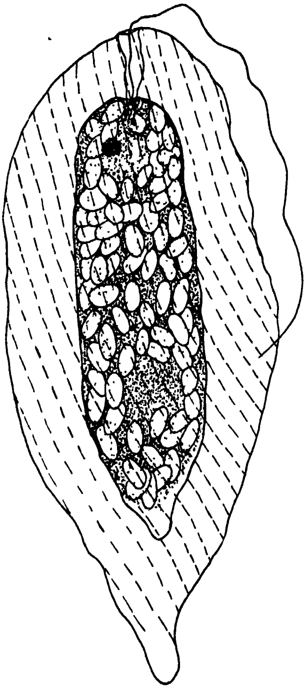
The purpose of the present investigation is to describe the reaction of *Euglena rubra* to Noland's 1928 stain and fixative and to offer a possible explanation of the phenomenon.

Method

A drop of the medium containing the organisms was placed on a slide, and two drops of Noland's temporary stain for demonstrating flagella and cilia were added to the original drop. The composition of the fixative and stain includes 80 cc. of a saturated solution of phenol in water, 20 cc. of a 40 percent solution of formaldehyde in water, 4 cc. of glycerine, and 20 mgms. of gentian violet, moistened before adding (Noland, 1928).

Observations

From approximately forty species of Euglena treated with Noland's fixative and stain, the pellicle separates from the protoplast only in *Euglena rubra*. The flagellar attachment remains intact and the striations of the separated pellicle are prominent in all organisms. The distance separating the pellicle from the protoplast is one-fourth or more the diameter of the protoplast (Fig. 1, 2). The space between the plasma membrane and pellicle may or may not appear vacuolated (Fig. 1, 2). Any pressure which tends to separate the pellicle from the protoplast may be relieved by forcibly breaking the pellicle, and under these conditions no contraction of the pellicle occurs after release of the internal pressure. Measurements comparing living and stained organisms



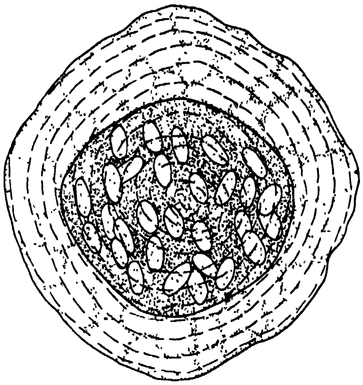


Fig. 1. Trophozoite of *Euglena rubra* in which the pellicle has become separated from the protoplast after treatment with Noland's 1928 temporary fixative. (330X).

Fig. 2. Resting cyst of *Euglena rubra* after treatment with Noland's 1928 temporary fixative, showing vacuolated area between protoplast and pellicle. (330X).

indicate that the volume of the protoplast is decreased only slightly, if at all.

The separation occurs in resting cysts and trophozoites, but never in the more permanent cysts in which the gelatinous wall beneath the pellicle is much thicker than in resting cysts. The reaction seldom occurs in every organism of any one preparation.

Discussion

Euglena rubra, like most Euglenoids, possesses two means of locomotion, flagellar and metabolic (euglenoid) movement. The striations of the pellicle are generally thought to contain elastic elements, which tend to retain the form of the organism during and after contraction of the superficial layers of the body. *Euglena rubra* when immersed in Noland's stain and fixative apparently lose their normal elasticity and therefore are unable to return to their original condition. The failure of the pellicle to regain its original size even after the pellicle has been burst and the internal pressure released, warrants the conclusion that the pellicle is contractile in the living organism and that the solution caused the destruction of that elasticity. It is probable that the homologous elements in other Euglena lose their elasticity, but that conditions which are necessary to demonstrate that loss of elasticity are lacking in those Euglena. It would seem that a combination of a certain physiological state of the protoplast or associated portions, and a certain lack of elasticity of pellicle is necessary before the separation of pellicle from protoplast occurs.

This physiological condition may be correlated in some way with the sol-gel state of the cyst wall, since the separation of pellicle from protoplast occurs in resting cysts but not in thick-walled cysts. It may be that the thick cyst wall, when treated with the immersion fluid, fails to exert an osmotic pressure great enough to cause the reaction, yet the resting cyst and trophozoites are capable of such. Or, it may be that the fixative reaches the plasma membrane of the trophozoite and resting cyst, causing a change in the permeability of the membrane, but fails to reach the plasma membrane of the thick-walled cysts. If that is the situation, some of the osmotically active salts would pass outside the plasma membrane, where they exert their osmotic activity. This seems unlikely, since a loss of salt large enough to cause the phenomenon would be followed by a corresponding loss in cell sap and a definite shrinking of the protoplast, which does not occur.

Summary

1. The separation of the pellicle from the protoplast of *Euglena rubra* is described.
2. Evidence is presented that the pellicle in the living organism is an elastic structure.
3. A possible explanation of the separation phenomenon is given.

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INHERITANCE OF PITTED EAR THROUGH SIX GENERATIONS

George C. Huff and Winifred Brillhart

Several papers have appeared in recent years on the inheritance of ear pit (Fistula auris congenita), but despite the accumulation of data over a long period of years, the problem of the mechanism involved in hereditary transmission of ear pit is not comcompletely satisfactory.

In the summer of 1941, quite by chance, it was learned that a certain family is proudly conscious of the "family mark." The first question asked by members of the family at the birth of a new infant is, "Does it have the family mark?" Additional questioning showed that the "mark" was a typical ear pit, unilateral or bilateral. From this chance original contact, it was finally possible to develop a pedigree of that family covering six generations from 1786 to 1941, including the records of one-hundred and seventy-nine individuals.

Most investigators have suggested that pitted ear is inherited as a dominant, and because the characteristic has been observed to skip a generation, the term "irregular dominance" has been used. An examination of published pedigrees (Whitney, 1939), (Connon, 1941) shows that couples in which either the husband or the wife showed the characteristic, had fifty children of which twenty-three showed the pitted condition and twenty-seven did not. On the basis of this distribution, the irregular dominant explanation is certainly tenable.

In the family under present investigation, parents, one of which showed the defect, had twenty-one children of which only four showed the pitted ear; which by itself may indicate that more is involved than a simple irregular dominance, or that ear pit is not inherited in the same way in all cases.

It is to be hoped that the addition of this pedigree to the accumulated data and future observations may clarify the mode of inheritance of pitted ear.

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AN ANOMALY IN THE CAT

Fae M. Shawhan

The purpose of this paper is to report a case of diaphragmatic hernia which was observed in the study of an embalmed cat received by the Zoology Department of Drake University.

There is no attachment of the diaphragm to any portion of the ventral body wall, although the diaphragm is apparently fully formed and attached both laterally and dorsally. Most of the alimentary canal lies in the thoracic cavity. This includes all of the ileum, all but a small portion of the duodenal loop, and an inch of the large intestine beyond the caecum. All of the pyloric and a portion of the cardiac stomach is anterior to the diaphragm.

The great omentum, normally cavering the intestine ventrally, is located in the thoracic cavity between the misplaced intestine and the heart. The gastrophepatic or lesser omentum, normally extending caudad from the liver to the pyloric portion of the stomach and the duodenum, lies primarily anterior to the diaphragm. Since a large part of the spleen is anterior to the diaphragm the gastro-lineal ligament, between the spleen and cardiac division of the stomach, largely lies in the thoracic cavity.

The heart is reduced in size and is situated definitely in the left half of the thoracic cavity, rather than in the usual median position. It is about an inch posterior to the normal location.

Three lobes of the liver are anterior to the diaphragm and two posterior to it. Those in the thorax are much reduced in size. One lobe extends far enough anteriorally to cover ventrally, the entire posterior portion of the heart. The gall bladder is situated anterior to the diaphragm, and both the bile and pancreatic ducts enter that portion of the duodenum which is in the thoracic cavity.

The lungs are very much crowded and reduced in size, but otherwise appear to be normal. The right lung is pushed into a more median position, with one of the right lobes of the liver occupying part of the space normally occupied by the lung. Aside from a general reduction in size, the ovaries, kidneys and their ducts appear to be normal in structure and position.

The ventral portion of the diaphragm, which is the region where this hernia has occured, is formed embryogically from the septum transversum. The lateral regions are formed from the pleuroperitoneal membrane, and derivatives from the body wall. The dorsal median area comes from the dorsal mesentery. From the standpoint of embryonic development, it seems possible that the ventral portion of the diaphragm may not have developed normally from the septum transversum.

Summarizing: There is no connection in this cat of the ventral side of the diaphragm with the ventral body wall. There is no spread or opening in the diaphragmatic muscles fibers themselves. With the exception of the urogenital organs and a portion of the large intestine, all the abdominal viscera have migrated to the thoracic cavity.

Three possibilities present themselves: First, the possibility of force, perhaps through accidental rupturing of this portion of the diaphragm, this force pushing these organs into the thoracic cavity; Second, the possibility that the unusual position of these organs has been brought about through freak embryonic development; Third, force, perhaps through accident, exerted against a weak or improperly formed ventral portion of the diaphragm in its embryonic development from the septum transversum.

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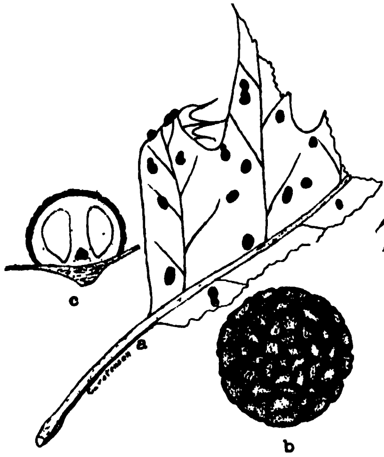
A PRELIMINARY STUDY OF THE INSECT GALLS OF IOWA

Gordon Carstensen and H. E. Jaques

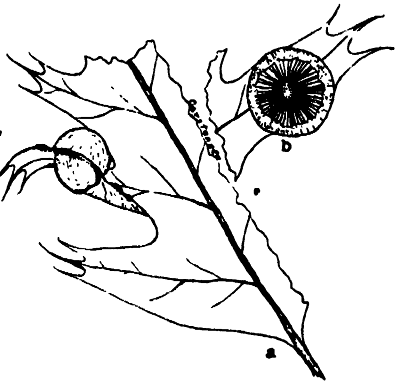
The abnormal growths frequently found on plants and known as insect galls have led to much study of their origin and manner of development. These abnormal plant structures may vary from a simple fold-like gall on a leaf to a highly complex structure resembling a fruit. Insect galls are found on at least 80 families of American plants. Some twelve plant families account for a large percentage of the known galls. Insects produce galls on many species of plants. Practically every part of a plant such as roots, stem, twigs, leaves, buds, flowers and fruits may develop galls.

The study of galls has led to much speculation as to the causative agents in their development. Nature's function of the gall is to furnish food and shelter for the insect host. These advantages are sometimes shared with insects of other species which are housed in the gall as secondary hosts or parasites of the gall-maker. The nature of the gall development is not the same for all galls. A relatively few galls are made by the cambium borers which, by girdling a stem or branch, cause the formation of wound tissue by the plant. This increased growth of wound tissue results in an enlargement known as a plant gall. A number of gall insects occupy cells in apparently normal stems or twigs and produce little or no enlargement of the infested part of the plant. A large number of comparatively simple galls seem to result from local irritation. This irritation stimulates the surrounding cells to increase growth.

A large number of galls develop in such a manner as to give the appearance of a nearly independent organism and show little relation to the plant structure from which they arise. These galls have a general structure that is analogous to that of a seed, the gall-maker taking the place of the seed and this in turn surrounded by nutritive and protective layers of plant tissue. Such galls are quite definite in size and structure for each species and the plant tissues appear to be dominated by the stimulus of the gall-maker. The production of these galls is dependent on the availability of enough meristematic tissue to permit the growth of the deformity from cells that would otherwise develop normally. The stimulus must be great enough to bring about a marked increase in the number of cells as compared to the number that would normally be formed. The exact nature of this stimulus is as yet unknown but is thought to be some substance that the adult insect or its larva injects into the plant tissue.



Oak Pill Gall
Cincticornia pilulae O. S.
(a) Showing gall on leaf.
(b) Enlarged gall.
(c) Cross-section of gall.



Small Oak Apple
Andricus singularis (Bass)
(a) Showing gall on leaf.
(b) Opened gall showing radiating fibers and larval cell.

Galls produced by a given species of insect are nearly always the same in relation to size and structure. The gall will vary a slight amount according to where the gall is developed on the plant but the main characteristics of the gall will not be changed. The fact that the characteristics do not vary is the basis for the identification of the insect galls.

Nearly all of the gall producing insects are found in three main groupings, the aphids, the gall midges and the gall wasps although some mites, thrips, beetles, moths and true bugs play a part in gall-making. The aphids or plant lice have several gall-producing species among them the very destructive grape Phylloxera. The gall midges of the order Diptera produce galls on many species of plants and include several species of economic importance. The gall wasps or Cynipids are small Hymenopterous insects that primarily inhabit the various oaks.

The following list of galls are known to occur in the state. This list should be understood to be quite incomplete but is given as a basis for further work on these interesting insects.

Order- Homoptera
Family- Chermidae
Pachypsylla celtidis-mamma Riley
Family- Phylloxeridae
Phylloxera caryaecaulis Fitch
P. vitifoliae Fitch
Order- Lepidoptera
Family- Gelechiidae
Gnorimoschema gallaesolidaginis Riley
Order- Diptera
Family- Cecidomyia
Rhabdophaga strobiloides Walsh.
Dasyneura communis Felt
Cincticornia pilulae O.S.
Parallelodiplosis florida Felt
Itonida foliora Rssl. & Hkr.
Cecidomyia citrina O.S.
Family- Syrphidae
Platycheirus quadratus Say
Family- Trupaneidae
Eurosta solidaginis Fitch
Order- Hymenoptera
Family- Cynipidae
Neuroterus noxiosus Bass.
Diplolepis ignota (Bass.)
D. palustris (O.S.)
Disholcaspis globulus (Fitch)
Xanthoteras forticorne (Walsh)
Acraspis pezomachoides (O.S.)
A. erinacei Walsh
A. villosa Gill.
Andricus singularis (Bass.)
A. peliolicola Bass.
A. robustus Weld
A. pisiformis Beautm.
Diastrophus cuscutaeformis O.S.
Aulacidea podagrae (Bass.)
Gonaspis potentillae Bass.
Rhodites rosae (L.)

IOWA WESLEYAN COLLEGE,
MT. PLEASANT, IOWA

A PRELIMINARY LIST OF THE CUTWORMS KNOWN TO OCCUR IN IOWA

ELIZABETH JERRELL AND H. E. JAQUES

For the past two years the writer has been giving special attention to collecting and rearing life histories of the members of the Family Noctuidae to which the cutworms belong, and in studying their taxonomy. There are over 2600 species of this family in the United States. Noctua is the Latin word for "owl:" these moths fly by night and some have shiny eyes, hence they are called "owlet" moths. Like the adults, the larvae feed at night. The larvae may be distinguished from white grubs (*Phyllophaga sp.*) which are often erroneously called cutworms by the presence of prolegs on the abdomen. Cutworms curl up, head to tail, when at rest or disturbed. Because of the difficulty of distinguishing the harmful species from those which are relatively harmless, there has been appended to this paper a list of the Noctuids up to the genus *Catocala,* which should include the species commonly designated as cutworms.

In the typical Noctuids, the body is large in proportion to the size of the wings; the front wings are strong, somewhat narrow and elongated, and when at rest the wings are furled upon the abdomen, giving the insect a triangular appearance. In the majority of the species, the scales on the dorsal surface of the thorax are turned up, more or less, forming tufts.

In the larvae of the majority of species there are five pairs of abdominal prolegs, but in three subfamilies the first and second pairs of abdominal feet are aborted and the larvae are semi-loopers. The most common forms of cutworms are fat, soft-bodied, smooth, round caterpillars, usually pale or dirty gray or black, and are sometimes spotted or striped. Cutworms attack a great many species of plants being practically omniverous in tastes. They work at night, usually cutting off the young plants at the surface of the ground, although some species are in the habit of climbing young fruit trees and eating the leaves and terminal shoots.

The females deposit their eggs on or near the ground, and the larvae, after hatching, feed on any green plants available.

Some forms become almost full grown by fall, pass the winter in the soil in the larval stage, and come out early in the spring, destroying many of the young plants. The pupa stage is of variable duration, depending on the species and the weather. Prompt action is necessary for controlling cutworms after they appear in the spring. Among the remedies employed for controlling cutworms are poisoned Bran Bait, culture of the soil, and use of hogs and poultry which root up and devour the larvae in large quantities.

Perhaps one of the best known cutworms is the Army worm, *Leucania unipuncta,* which may be used to portray the general habits. These worms are dark green in color with white stripes on the sides and down the middle of the back. The winter is passed in the partly grown larval stage, although the fact that the moths are abroad very early in the spring would indicate some of the insects winter as adults or pupae. They begin feeding early in the spring and by the first of May are full grown, pupating just below the surface of the soil. The pupae are dark brown, about ¾ inches long. The pupal stage lasts about two weeks, after which they emerge as pale brown or gray-brown moths with a wing expanse of 1½ inches. The identifying mark of the adults is a small but prominent white dot in the center of each front wing. The eggs, about 500 being laid by each female, are laid on the lower leaves of grasses in long rows. The worms are nearly 1½ inches long, of a greenish brown color with longitudinal stripes. Seen from the side there are three stripes of equal width, one orange, the next brown, and the third orange. The head is striped with dark lines and each proleg has a dark band on the outer side and a dark tip on the inner side.

For some twenty years the department has been making general collections of insects throughout the state in an effort to determine their geographic and seasonal distribution. The accumulated information of this specific group must be recognized as only fragmentary but a list of the known species is being published as an aid to any who are interested in this part of the family Noctuidae. The list includes 171 species of Noctuids among which will be found the cutworms.

1135 *Charadra deridens* Gn.
1140 *Raphia abrupta* Grt.
1141 *R. frater* Grt.
1147sp. *Acronicta* sp.
1148 *A. americana* Harris
1153 *A. lepusculina* Gn.
1155 *A. innotata* Gn.
1162 *A. falcula* Grt.
1172 *A. vinnula* Grt.
1182 *A. interrupta* Gn.
1183 *A. lobeliae* Gn.
1191 *A. inclara* Sm.
1194 *A. increta* Morr.
1196 *A. caesarea* Sm.
1215 *A. oblinita* A. & S.
1216 *A. lanceolaria* Grt.
1222 *Simyra henrici* Grt.
1223 *Harrisimemna trisignata* Wlk.

1296 *Euxoa velleripennis* Grt.
1310 *E. messoria* Harris
1341 *E. tessellata* Harr.
1380 *Chorizagrotis socorro* Barnes.
1387 *C. auxiliaris* Grt.
1394 *Loxagrotis apicalis* Grt.
1414 *Feltia malefida* Gn.
1416 *Agrotis vetusta* Wlk.
1422 *A. gladiaria* Morr.
1425 *A. venerabilis* Wlk.
1435 *A. ypsilon* Rott.
1442 *Feltia ducens* Wlk.
1445 *F. subgothica* Haw.
1446 *F. herilis* Grt.
1472 *Spaelotis clandestina* Harr.
1474 *Choephora fungorum* G. & R.
1480 *Ochropleura plecta* L.
1496 *Peridroma margaritosa* Haw.
1496b *P. margaritosa* form *saucia* Hbn.
1520 *Graphiphora badinodis* Grt.
1523 *G. bicarnea* Gn.
1525 *Graphora tenuicula* Morr.
1593 *Agabrotis placida* Grt.
1611 *Ufeus satyricus* Grt.
1615 *U. unicolor* Grt.
1633 *Scotogramma trifolii* Rott.
1654 *Trichoclea mojave* Benj.
1655 *T. artesta* Sm.
1670 *Polia distincta* Hbn.
1671 *P. distincta* Hbn.
1683 *P. legitima* Grt.
1691 *P. adjuncta* Bdv.
1709 *P. detracta* Wlk.
1709a *P. detracta neoterica* Sm.
1712 *Lacinipolia meditata* Grt.
1735 *L. vicina* Grt.
1738 *L. renigera* Steph.
1744 *L. lorea* Gn.
1745 *L. olivacea* Morr.
1800 *Sideridis rosea* Harv.
1821 *Tricholita signata* Wlk.
1848 *Orthodes incincta* Morr.
1849 *O. rufula* Grt.
1871 *O. crenulata* Butl.
1872 *O. cynica* Gn.
1895 *Nephelodes emmedonia* Cram.
1895a *N. tertialis* Sm.
1904 *Morrisonia confusa* Hbn.
1943 *Orthosia hibisci* Gn.
1943.1 *O. hibisci* f. *insciens* Wlk.
1951 *Ceramica picta* Harr.
1962 *Protoleucania albilinea* Hbn.
1962a *P. albilinea diffusa* Wlk.
1973 *Leucania pseudargyria* Gn.
1974 *L. ursula* Forbes
1977 *L. commoides* Gn.
1978 *L. phragmatidicola* Gn.
1982 *L. multilinea* Wlk.
1992 *L. insueta* Gn.
1994 *L. unipuncta* Haw.
1995 *L. luteopallens* Sm.
2038 *Cucullia intermedia* Speyer
2044 *C. asteroides* Gn.
2147 *Homohadena badistriga* Grt.
2153 *H. infixa* Wlk.
2153 *Graptolitha antennata* Wlk.
2155 *Adita chionanthi* A. & S.
2195 *Eutolype depilis* Grt.
2196 *E. rolandi* Grt.
2220 *Grapholitha bethunei* G. R.
2221 *G. innominata* Sm.
2225 *G. disposita* Morr.
2278 *Fishia evelina* French
2304 *Eupsilia sidus* Gn.
2305 *E. morrisoni* Grt.
2312 *Rusina bicolorago* Gn.
2312.1 *R. bicolorago ferrugineoides* Gn.
2335 *Septis lignicolora* Gn.
2351 *S. arctica* Frr.
2355 *S. inordinata* Morr.
2366 *Agroperina lateritia* Hufn.
2370 *A. inficita* Wlk.
2373 *A. lutosa* Andr.
2374 *A. helva* Grt.
2375 *Crymodes devastator* Brace.
2379 *C. burgessi* Morr.
2383 *Protagrotis niveivenosa* Grt.
2400 *Aseptis binotata* Wlk.
2422 *Oligia diversicolor* Morr.
2426 *O. fractilinea* Grt.
2437 *Spartiniphaga includens* Wlk.
2440 *Archanara subflava* Grt.
2457 *Helotropha reniformis* Grt.
2458 *Apamea velata* Wlk.
2459 *A. americana* Speyer
2475 *Hydroecia perobliqua* Hamp.
2476 *H. stramentosa* Gn.
2478sp. *Papaipema* sp.

2479 *P. appassionata* Harv.
2484 *P. marginidens* Gn.
2508 *P. lysimachiae* Bird
2510+*Acronycta* sp.
2510 *Papaipema cataphracta* Grt.
2525 *P. nebris* Gn.
2525.1 *P. nebris* f. *nitela* Gn.
2528 *P. maritima* Bird
2535 *Phlogophora iris* Gn.
2546 *Macronoctua onusta* Grt.
2554 *Chytonix palliatricula* Gn.
2573 *Prodenia eridania* Cram.
2574 *Laphygma frugiperda* A. & S.
2576.1 *Leuconycta diphteroides* f. *obliterata* Grt.
2576 *L. diphteroides* Gn.
2582 *Agriopodes teratophora* H.S.
2584 *Amphipyra pyramidoides* Gn.
2586 *A. glabella* Morr.
2610 *Perigea xanthoides* Gn.
2611 *Monodes grata* Hbn.
2613 *Platysenta videns* Gn.
2617 *P. apameoides* Gn.
2638a *Apamea nictitans americana* Speyer
2647 *Elaphria festivoides* Gn.
2650 *E. grata* Hbn.
2651 *Anorthodes tarda* Gn.
2657 *Platyperigea meralis* Morr.
2661 *Crambodes talidiformis* Gn.
2662 *Proxenus miranda* Grt.
2666 *Galgula partita* Gn.
2677 *Prodenia dolichos* Fabr.
2669 *Balsa malana* Fitch.
2678 *Prodenia ornithogalli* Gn.
2678.1 *P. ornithogalli* form *eudiopta* Gn.
2682.2 *Laphygma frugiperdo* f. *obscura* Riley
2683 *L. exigua* Hbn.
2687 *Cosmia canescens* Behr.
2694 *Amolita fessa* Grt.
2703 *Arzama obliqua* Wlk.
2705 *A. densa* Wlk.
2737 *Catabena lineolata* Wlk.
2773 *Ogdoconta cinereola* Gn.
2803 *Stiria rugifrons* Grt.
2827 *Euthisanotia grata* Fabr.
2858 *E. grata* Fabr.
2832 *Stiriodes obtusa* H. S.
2860 *Euthisanotia unio* Hbn.
2864 *Psychomorpha epimenis* Dru.
2895 *Lithacodia albidula* Gn.
2929 *Heliothis paradoxa* Grt.
2931.1 *H. phloxiphaga,* form *luteitinctus* Grt.
2932 *H. obsoleta* Fabr.
2933 *H. virescens* Fabr.
2934 *Canthylidia scutosa* Schiff.
2938 *Dasypoudaea lucens* Morr.
2939 *D. meadi* Grt.
2956 *Schinia cumatilis* Grt.
2966 *S. trifascia* Hbn.
2990 *S. nundina* Dru.
3007 *S. marginata* Haw.
3014 *S. jaguarina* Gn.
3018 *S. arcigera* Gn

IOWA WESLEYAN COLLEGE,
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THE MEASUREMENT OF VISUAL PHENOMENA BY MEANS OF THE ELECTRORETINOGRAM.

THEODORE LOUIS JAHN

Whenever light strikes the eye of an animal there is a voltage difference produced between the front and back of the eye. This voltage difference originates in the retina of the vertebrate eye and in the sense cells of the compound eye. A record of the voltage change may be obtained by means of an oscillograph and is referred to as an electroretinogram (ERG). The electroretinogram may be used for the study of various visual phenomena. These are:

1. Relative sensitivity of the eye to different wave lengths of light. This may be obtained by plotting the magnitude of the electrical response against wave length of stimulating light or by plotting the intensity necessary to give a certain magnitude of response against wave length.

2. Color vision. By means of microelectrodes the response from individual ganglion cells in the vertebrate retina can be measured. The sensitivity-wave length curves for various ganglion cells of an animal are different, and this difference is apparently the physical basis of color vision.

3. Rate of dark adaptation. After continued exposure to a bright light the response of an eye to brief exposures is very small. As dark adaptation proceeds the response increases. In the case of simple responses the magnitude of the ERG is a measure of the sensitivity of the eye and when plotted against time is a measure of the dark adaptation process. This is a measure of the rate at which the visual pigment (visual purple in vertebrates) is regenerated after being decomposed by light.

4. Light adaptation. The sensitivity may be determined at various times during the process of light adaptation, and the rate at which the visual pigment is decomposed by light may be calculated.

5. Threshold sensitivity. The minimum amount of light which will barely give a detectable electrical response can be measured. For the Dytiscus beetle this threshold differs by a factor of 1000 between day and night. The eye is about a thousand times more sensitive at night even when maintained under conditions of constant darkness (except for test flashes), temperature, and humidity. This is evidence of an inherent diurnal rhythm which is ap-

parently governed by some undetermined biological clock in the animal.

6. Flicker fusion frequency. If an eye is subjected to a flickering light of variable frequency, fusion of ripples in the ERG will occur at a definite frequency which is apparently directly related to the frequency at which fusion of the visual image occurs. By measuring this frequency at different intensities a flicker fusion contour for the animal may be obtained. In Dytiscus this contour is different during the day and during the night under comparable conditions of adaptation—more evidence of the biological clock.

7. The ERG of insects very often contains high frequency oscillations (5 to 60 per second) which originate in the optic ganglion. These oscillations are of many types and apparently result from stimulation of different types of sense cells in the eye, some of which are active during illumination, some only at the beginning of illumination, and some only at the cessation of illumination. As recorded from either the eye or ganglion these oscillations are directly comparable to the cortical potentials of vertebrates.

In the study of human vision, measurements of visual phenomena may be made more easily by use of the sensations of the subject. However, in the case of certain diseases of the eye where sensations are not perceived, it will apparently become possible to determine electrically the functional state of the eye independent of the sensations of the individual. Nevertheless, it is among the lower animals that the electrical method will be of greatest usefulness, because it completely eliminates the necessity of studying the reactions of the animal to various stimuli. It is a purely objective method for which we need only the eye of the animal and the appropriate electrical equipment.

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AN ANOMALOUS CHICK EMBRYO PULSATING AS A HEART

WILLIAM M. GOLDSMITH AND DAYRLE N. CRABB

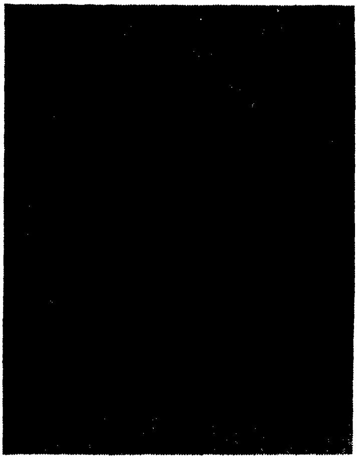
During the regular laboratory work in embryological technique, the finding of anomalous chick embryos is so common that little interest is attracted. However, when one student reported the rhythmic beating of a solitary chick heart apparently without the accompanying chick, special interest was stimulated. This strange pulsating bit of protoplasm was noted in an egg of about 50 hours incubation. It was transferred to warm, normal physiological saline solution and observed for fifteen minutes. The beating was not unlike that of a normal chick heart of corresponding age. In order to assure a good fixation, the specimen was removed from the yolk and placed in Bouin's fluid, stained in Borax Carmine and mounted in toto on a slide by the usual borax carmine method.

Figures 1 and 2 show the specimen in photograph and pen sketch respectively. The blastoderm was omitted in the drawing and much of the photograph because of the normality of its appearance and functioning.

The embryo, as viewed from the dorsal surface, will remind one of a contracted Euglena that is almost as wide as it is long and possesses a flagellumlike tail. This so-called tail was first thought to contain blood vessels connecting the blastoderm with the mass of protoplasm, but later examination of its cross-section proved it to be composed of only the amnion and filled with its fluid. The lighter lateral areas of the embryo, as shown in the photograph, constituted the somatopleure, splanchnopleure, amnion, and chorion. The central portion, extending from anterior to posterior, shows an attempt at organization, but with very little success.

The dark, anterior, median, portion was found to be located below the splanchnopleure, apparently lying in the yolk, thus dividing the body into a dorsal and ventral half in that area, with the posterior end of the ventral half attached to, and finally absorbed by, the dorsal half. We were prone to believe that the ventral half could have been the loop of the heart as it contained two large vessels as shown in the cross-section. (Figure 3).

When the study of the whole mount was completed, the specimen was demounted, imbedded in paraffin, cut in cross-sections of seven microns thickness, and mounted on slides for study. The



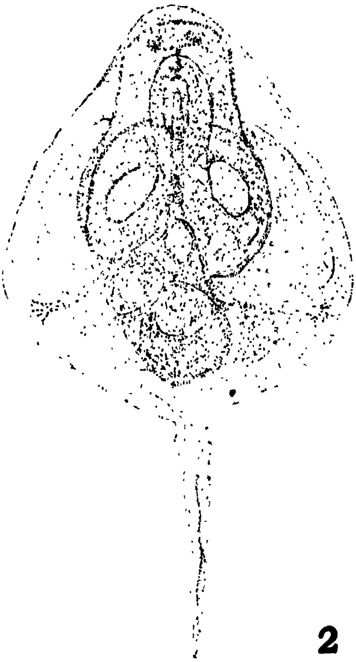


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Fig. 1 and 2. Photograph and drawing respectively showing specimen in wholemount.

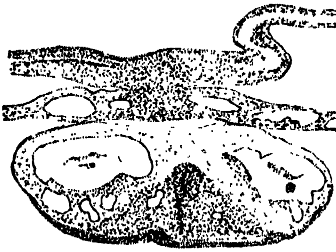

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Fig. 3. Showing ventral and dorsal halves, fold of the amnion, somatopleure and splanchnopleure, (266 micron area).

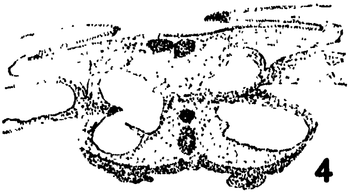

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Fig. 4. The uniting dorsal and ventral halves with notochord and masses of tissue in neural tube area, (555 micron area).

cross-sections were counted to determine the length of the specimen from the anterior end to the posterior end at the base of the tail. By multiplying the numbers of cross-sections with the thickness of each section we determined the length to be 1558 microns and the aproximate width 1307 microns.

At the anterior end we find the amnion and chorion forming in folds on each side of the embryo and gradually coming together in the 600 micron area and remaining normal throughout the rest of the embryo. These tissues are histologically normal. The amnion, as was previously mentioned, is the only tissue forming the tail and lies above and unattached to the splanchnopleure or what now may be called the blastoderm.

The somatopleure and splanchnopleure are, without a doubt, the most typical and normal areas of the complete chick embryo. However, the splanchnopleure is not related to, nor does it take part in, the formation of the folds which form the "probable" foregut, which is located on the ventral surface of the ventral half. The folds first appear at 434 microns and unite at 600 microns from the anterior end.

The notochord and neutral tubes are first formed in the ventral half and the dorsal half respectively. The notochord appears to be mediumly normal but as the ventral portion united with the dorsal portion the notochord elongates in the 600 micron area to unite with the undifferentiated mass in the neural tube area. This is quite important as its disintergration is the beginning of a line bisecting the two lateral areas.

The vascular system is the strangest phenomenon of this specimen. We have termed the ventral half of the anterior portion the true pumping organ. We know it contains one vessel of changing shapes and formations that makes a "U" turn and returns on the other side of the ventral half. (Figure 3). This body is the only muscular area which could act as the pumping organ and starts to unite with the dorsal half in the 544 micron area (Figure 4). The vessels in the lower ventral half unite with two vessels in the splanchnopleure area of the dorsal half. The ventral half migrates dorsally until it is completely absorbed by the upper half in the 740 micron area. These vessels migrate into the somatopleure and come to a "dead end" in the 1280 micron region. The completion of the foregut gives rise to two tubes which unite, in a few microns space, and continue dorsally as one to unite with another in the splanchnopleure. This last is connected with the blastoderm but does not form a complete circulatory system.

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TREPANATION AND THE "CATLIN MARK"

WILLIAM GOLDSMITH

This paper deals with the confusion of a certain anomalous condition of the human skull with one type of trepanation. Many skulls with an opening in each parietal bone should not be cited as examples of trepanation, but rather clear cut cases of the "Catlin Mark" of Goldsmith, or more technically referred to by other writers as: *"Large Bilateral Parietal Foramina"*, *"Foramina Parietalia Permagna"*, or *"Fenestrae Parietales Symmetricae"* of Halbertsma.

The writer cites cases (hereditary and otherwise) where individuals are born with paired holes in varying size in the parietal bones. Photographs of a calvarium from dissection at Tulane University and pictures and X-rays from living or recently deceased adults indicate that many cases of so-called "ancient trepination" are mislabeled. Cases of certain frontal fenestrae and other skull anomalies are pictured and cited for further study as possibly illustrating developmental defects rather than trepanation. Photographs and X-rays are presented to show the differential diagnosis between congenital openings and man-made trepanations.

UNIVERSITY OF DUBUQUE,
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DIRECTIONS FOR THE PREPARATION OF MANUSCRIPTS FOR PUBLICATION IN THE PROCEEDINGS OF THE IOWA ACADEMY OF SCIENCE

In order to establish uniformity of style and to facilitate the editorial work of the Iowa Academy of Science the following directions are given.

1. Authors who submit papers for publication are expected to be members of the Academy in good standing. Persons elected at the current meeting are so considered.

2. All papers for publication from each section are to be in the hands of the chairman immediately following the close of the meeting. They should consist of clean, double spaced, *typewritten first copies.*

3. The plan of the papers should be as follows: title, author, body of the paper, summary (if desirable), author's address, and cited literature.

4. The title of the paper should be made as brief as possible and typed in capital letters.

5. Tables, figures, and graphs should be numbered and correspond to the numbers in the text. Each figure or graph should have a legend, and each table a caption.

6. Illustrations that are not to be set up in type should be prepared large enough to be reduced one-third or one-half. Lettering and numbering should be done with the aid of guides or by one capable of doing acceptable drafting. Graphs can be made on red ruled graph paper. All ink work is to be done with undiluted india ink. Photographs should be prepared on glossy paper and should have high contrast. If several photographs are used as a single plate they should be trimmed, fitted closely together and mounted with rubber cement upon stiff white cardboard. The plate should be large enough to allow for at least one-third reduction. On the back of each table, figure, or graph, indicate the author.

7. Footnotes are difficult to edit and should be reduced to a minimum. Incorporate this material in the text.

8. Literature citations should be made as follows: In the text the citation is made by author and year, i.e., (De Coursey, 1927),

and in the bibliography should be cited as follows: author, year, title of paper, journal, volume, pages, i.e., (*note punctuation*).

De Coursey, R. M. 1927. A bionomical study of the cluster fly, *Pollenia rudis* (Fab.). Ann. Ent. Soc. Amer. 20:368-384.

When a book is cited care should be taken to include the name and address of the publishing company, i.e.,

Snodgrass, R. E. 1935. Principles of insect morphology. McGraw-Hill Book Co., New York.

9. If the paper is several pages in length a summary may be desirable. This should be brief, written in complete sentences, and conclusive.

10. At the close of the manuscript indicate the author's address (department, college or university, or home), city and state. Also give the author's summer address, and in cases where traveling is anticipated, the place to which the editor may send the galley proof. A state contract requires the editor to make corrections and return the galley proof to the printer if authors fail to make immediate corrections. Only typographic errors can be corrected at Academy expense.

11. Abstracts for publication by the Academy should be brief, informative summaries. Illustrative matter should not be submitted with abstracts.

12. The editor cannot without the consent of the editorial committee release any paper after it has been submitted for publication.

L. R. Wilson,
Coe College,
Cedar Rapids, Iowa

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